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Report on the *Pandalus* Assessment Working Group

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ICES Headquarters, Copenhagen, Denmark

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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0 Executive Summary

0.1 ToR

The ICES *Pandalus* Assessment Working Group [WGPAND] met in ICES HQ, 27 Oct. – 4 Nov. Five participants from four countries attended the meeting, representing Denmark, Norway, Sweden and Russia. The terms of reference for the Working group were: to carry out assessments of the stock of *Pandalus* in Skagerrak and the Norwegian Deeps (IIIa & Iva East) and the stock in the Barents Sea and Svalbard area (I & II) and to provide advice (catch options) for these stocks in 2005.

0.2 Assessments and state of stocks

0.2.1 *Pandalus* in the Skagerrak and Norwegian Deep (IIIa & IVa East)

In recent years the assessment of this stock has been based on a simple production model taking predation into account. The main input data to this model has been provided by a Norwegian trawl survey. However, because there has been a significant break in the data series in 2003, no update assessment could made this year due to missing assessment data. Furthermore, it has also been pointed out, that the model applied has not been optimal to the data available, see Sects 4.4 & 4.5.1.

The state of this *Pandalus* stock in 2004 and 2005 is presented in Sect. 4.5.3. It is based on WG considerations on trends in LPUE combined with the 2004 biomass index provided by a new Norwegian survey. The stock seems to be on the same, rather high, level as in recent years

0.2.2 *Pandalus* in the Barents Sea and Svalbard area (Sub-areas I & II)

Several models have been applied for assessment of this stock. However in recent years, the views on the state of the stock have been based on survey indices combined with trends in CPUE. SSB appears to have been declining in recent years, see Sect. 7.7.2.

0.3 The by-catch in the *Pandalus* fisheries

Sects. 8 & 9 give overviews of the by-catch based on mainly available logbook information

0.4 Working procedures

This years WG meeting was held jointly with NAFO Scientific Council/STACFIS shrimp assessment meeting at the same dates and at the same place (ICES HQ). The purpose of such joint meeting was to exchange views and experience in data and methodologies in assessments *Pandalus* stocks. However, it became clear, - and here was agreement among the NAFO and the ICES scientists -, that the scientific benefits were limited. This was mainly due to lack of crucial assessment input to the ICES WGPAND from one of the member countries. Thus, the basis for exchange and discussion of the assessments and methodology was severely constrained.

1 Terms of Reference

The terms of reference are according to 2003 Council Resolution 2ACFMND

Pandalus Assessment Working Group [WGPAND] (Chair: S. Munch-Petersen, Denmark) will meet at ICES HQ, Copenhagen, Denmark from 27 October to 5 November 2004 to:

- assess the status of the stocks of *Pandalus borealis* in the North Sea, Skagerrak and Kattegat and provide catch options for 2005 taking predation mortality on *Pandalus* stocks into account;

- for stocks for which a full analytical assessment is presented, comment on this meeting's assessments compared to the last assessment of the same stock.

- assess the status of the shrimp stock (*Pandalus borealis)* in the Barents Sea, taking predation by cod into account;

WGPAND will meet jointly with NAFO Scientific Council/STACFIS shrimp assessment meeting at the same dates and at the same place. NAFO Scientific Council, STACFIS and ICES WGPAND chairs will jointly agree on the meeting arrangements. The arrangements will be made with a view of limiting the meeting time for WGPAND) and in particular ensure that the assessment of the *Pandalus borealis* stock in the North Sea, Skagerrak and Kattegat will take the abundance survey results into account.

2 Participants

Aschan, Michaela	Norway
Berenboim, Boris	Russia
Eigaard, Ole	Denmark
Munch-Petersen, Sten (Chairman)	Denmark
Ulmestrand, Mats	Sweden

In addition, Knut Sunnanå (Norway) contributed with data and suggestions by correspondence.

2.1 The establishment of a joint NAFO-ICES *Pandalus* WG

This year's ICES *Pandalus* Working Group meeting was held jointly with the NAFO STACFIS shrimp assessment WG. Both groups felt that joint meetings would be of great benefit to the work of the groups. The purpose of such joint meetings is to provide greater peer review of the assessment of *Pandalus* stocks. In addition such meetings will allow the exchange of information on assessment methods and on shrimp population dynamics. Unfortunately this first attempt at a joint meeting was less than successful, with the number of joint sessions being far less than had been planned. Part of this problem was lack of crucial assessment data as well as poor information to the WGPAND members on these data problems prior to the meeting. As a result the meeting developed into parallel sessions with only few joint scientific sessions and this is not the optimal way for joint meetings to be held. However it was felt by both groups that this problem could be overcome in the future and that the success of future meetings would be enhanced by having preliminary assessments ready for all stocks at the beginning of the meeting.

It was agreed that a joint NAFO-ICES *Pandalus* WG should meet in October 2005. In order to facilitate future meetings the Chairs of Scientific Council, STACFIS and WGPAND will work together to prepare a proposal for a plan for future meetings. This proposal will first be reviewed by members of the two groups, intersessionally and then presented to Scientific Council at its June 2005 meeting. In devising such a plan the Chairs will consider the merits of running the STACFIS/WGPAND section of the meeting under a single chairmanship and they will also consider the possibility of incorporating review of methodological developments in future meetings.

3 Definition of Stock / Assessment units

3.1 The North Sea and Skagerrak

The distribution of *Pandalus* in the Entire North Sea area is shown in Fig. 3.1. The WG has, so far, maintained the view that shrimp caught on the Fladen constitute a stock separated from the *Pandalus* in the Norwegian Deeps and Skagerrak. The main arguments for this separation were presented in ICES (1990):

- Geographical separation combined with hydrographical considerations.

- The Fladen shrimp are normally characterized by fewer age groups This difference was quantified by multivariate analyses of length frequency distributions (LFD) from the three areas, these suggested that especially the Fladen LFDs deviate from the other two (ICES, 1990).

A close connection between the shrimp in the two areas has, however, been postulated by earlier investigations (e.g. Poulsen, 1970). It was done based on trends in size distribution of the shrimp in various parts of the entire North Sea – Skagerrak area and on probable larval drift with surface currents in the northern North Sea. The WG has, furthermore, observed that:

- Norwegian Survey data on recruitment for IIIa ,IVa East and LPUE in the Danish Fladen fishery is correlated pattern in LPUE fluctuations in the fisheries exploiting the two stocks have frequently been similar

This could indicate a close connection between the two stock units.

Improvements in genetic separation technologies in recent years could elucidate this particular stock separation problem. It is recommended that data for genetic analyses should be provided from the Norwegian trawl survey.

3.2 The Barents Sea and Svalbard area

The Pandalus stock in the Barents Sea and Svalbard area is distributed as shown in Fig. 3.2. Genetic investigations, allozyme electrophoresis and DNA-fingerprinting, have been conducted in attempts to identify potential sub populations of shrimp in the Northeast-Atlantic including the Jan Mayen area, the Norwegian coast, the Barents Sea and the Svalbard area (Kartavtsev et al. 1991, Rasmussen et al. 1993, Drengstig et al. 2000 and Martinez et al. 1997). The latter analyses showed that there are no distinct sub-populations in the open sea, and that there is a high degree of genetic variance between individuals within each location. However, genetic gradients related to geographic distance and sea currents have been identified. The transport pattern produced by the currents, varies between years, and results in annually different dispersion patterns of settled shrimp larvae. This may have a strong influence on the year class strength in sub-areas as well as in the entire Barents Sea.

The shrimp in the Barents Sea should be considered as one population, where female shrimp produce settling larvae in the whole distribution area. The transport of larvae secures genetic Flow within the population. The abundance of reproducing females in each sub area is of great importance for the annual recruitment and therefore management has to secure the spawning females throughout the Barents Sea (Pedersen et al. 2003).

4 The *Pandalus* Stock in Divisions IVa East and IIIa

4.1 The *Pandalus* fisheries in the North Sea and Skagerrak

4.1.1 The Danish *Pandalus* fishery

The Danish *Pandalus* fishery targets both the shrimp stock in the Sub-area IVa East and division IIIa and the one on Fladen Ground. In the period 1994 to 1999 the fisheries in the two areas were of about the same size, but since 2000 the landings from IVa-East + IIIa have been much higher and today they are almost three times the size of the landings from Fladen Ground. Interview information from the fishing industry obtained in 2004 gives the explanation that this shift in recent years is caused by poor fishery on the Fladen Ground (low abundance of shrimp) combined with low prices on shrimp and high prices on fuel. These latter conditions have further favoured fishing in waters close to landing harbours (Skagerrak) in order to minimize fuel costs.

During recent years an increasing number of vessels have started processing (boiling) the shrimp aboard and landing them in Sweden thus obtaining a better price. The majority of the catches are however still landed in Danish fishing ports. Most shrimp are landed directly to a few large factories processing almost all sizes of shrimp.

<u>The fishing vessels</u>

In a study performed by Ulrich and Andersen (2004) all Danish fishing vessel were grouped in categories based on similarities in catch composition, gear used and area fished. According to their analyses of log book data on catch, effort as well as landings from all the Danish fishing trips in 1999, a total of 14 vessels could be identified as being trawlers targeting *Pandalus* in the North Sea or Skagerrak. They accounted for the majority of the total landings and had an average of 68 yearly trips targeting *Pandalus*. A larger poorly defined vessel group occasionally took part in the *Pandalus* fishery, but only accounted for small catches of *Pandalus*.

This result is in agreement with the interview information where Skagen, Hirtshals and Hanstolm were pointed out as being the major harbours of *Pandalus* trawlers in 2004, Skagen being the home harbour of 6-7 vessels of approximately 100-200 GRT and Hirtshals and Hanstolm each having 2-3 somewhat larger *Pandalus* trawlers of between 200 and 300 GRT. The major landing harbours were the same. According to the interviewees the number of *Pandalus* trawlers had been slightly higher in previous years.

<u>Fishing Gear</u>

The largest net manufacturer in Denmark (Cosmos Trawls) provides shrimp trawls to many of the Danish vessels. At present the two most common trawls are the ”Sputnik” (or ”Skagerrak”) trawl and the ”Fladen shrimp” trawl, differing mostly with respect to the height of their trawl opening. The Sputnik trawl has almost twice the height as that of the Fladen shrimp trawl but only a slightly larger width. The two trawls are chosen by turn depending on fishing area and time. The mesh size in the cod ends used is almost exclusively 40 mm whole-mesh with a 70 mm square mesh window in the top panel.

This net manufactory also informed that within the last 5-10 years almost all trawlers had started fishing with twin trawls. This change had allowed the individual vessels to increase the swept area (wing end to wing end) with approximately 50% without resulting in increased demands to the vessels engine capacity or in any noticeable increase in fuel consumption.

4.1.2 The Norwegian *Pandalus* fishery

In 2002, a total of 143 trawlers were registered in three categories of shrimp trawlers conducting shrimp fishery mainly south of 62^{o}N. There were 45 vessels being less that 50 GRT and smaller than 13m in length delivering 980 t of shrimp from this area, there were 69 trawlers less than 50 GRT and longer than 13m, delivering 2770 t of shrimp and finally, there were 29 trawlers being larger than 50 GRT delivering 2330 t of shrimp. Vessels belonging to other categories also land some shrimp. According to the Norwegian logbook records for 2003, 38 vessels have reported shrimp catches and these vessels are all longer than 13m. Of the 18 vessels less than 50 GRT, 4 vessels deliver less than

10 t, 10 vessels between 10 t and 50 t, and 4 vessels more than 50 t. Of the 20 vessels larger than 50 GRT, 2 delivered less than 10 t, 3 between 10 t and 50 t, 5 between 50 t and 100 t and 10 more than 100 t.

In the Norwegian fishery for shrimp in this area the minimum mesh is 35mm. It is not allowed to fish in waters shallower than 60 m. It is allowed to have 50% by-catch of other market species. For cod and haddock combined there is a limitation that the number of undersized specimens may not exceed 8 per 10 kg of shrimp. It is allowed to have up to 10% undersized shrimp (< 6cm – 15mm carapace length) in the catch. Discarding is prohibited in the Norwegian waters. Due to these regulations, the trawlers fish a considerable by-catch of market fish. They also conduct other fisheries during the year, e.g. mackerel trolling. The larger vessels (>50 GRT) also conduct trawl fishery for sandeel and herring.

In 1999 a general quota regulation system was initiated in the Norwegian fishery. The total Norwegian quota is divided into periods of four months each with app. 1/3 of the quota each period. The quota for 2003 was set at 8040 t for the whole year. The vessels have a maximum quota each for each period, a trip-quota for each trip to sea and a mandatory number of days of no fishing between each trip. There is some variation depending on whether they are fishing for boiled landings or for shrimp to be landed fresh.

Two categories of shrimp dominate the market: Approximately 35% of the total landings is delivered as boiled or fresh large shrimp (140-150 individuals per kg) for the Norwegian inland market (app. 60%) and the Swedish market (app. 40%) and app 65% of the total as raw (smaller) shrimp for factory processing (mostly 180-250 individuals per kg). A price and quota regulation is in work to regulate the available shrimp for the Swedish market, for which there is an export quota free of toll. The fisher gets app. 55 NOK for boiled shrimp and app. 10 NOK for the raw shrimp. Some high grading and discarding is assumed to take place. Especially shrimp sized below 15mm carapace length are probably all discarded and may account for 5-10% of the catches (app. 6% in October 2003 based on the catches in the Norwegian survey).

4.1.3 The Swedish *Pandalus* fishery

In 2003, a total of 75 trawlers reported landings of *Pandalus* in the Swedish log books. Of these 52 landed more than 10 tonnes *Pandalus* and can be considered active in this fishery. 15 of these landed more than 50 tonnes and are specialized *Pandalus* trawlers, standing for about 50% of total Swedish *Pandalus* landings.

The size of the vessels ranges between 8-34 m (length) with an average of 18.7 m. GRT varies from 3 to 235), with an average of 81 GRT. The average engine effect is around 300 kW (44 kW-735 kW). The larger trawlers are normally fishing in the eastern and central part of Skagerrak. The smaller trawlers are mostly fishing in the Swedish coastal zone inside a ‘trawling border’ where special regulations apply for the use of trawls: Trawling is restricted to waters deeper than 60 m and there are special limits in the length of ground rope and in the size of the trawl and trawl doors. Furthermore, the trawls to be used inside this boarder must be equipped with a species selective Nordmøre grid of 19 mm bar space and an unblocked fish opening in the trawl roof. This has resulted in very clean landings from these trawls (99% *Pandalus*). The Nordmøre grid may also be used outside the trawling boarder as an alternative to the EU legislated 70 mm square mesh panel in shrimp trawls.

This particular *Pandalus* trawl can be distinguished from other shrimp trawls in the log books since 1997 and it seems that the effort of this gear has stabilized at about 12% of total *Pandalus* trawl effort in the recent two years, see also Table 8.1. There are two different Swedish markets for *Pandalus:* a) higher value boiled larger sized shrimp constituting around 50 % of the landings b) lower value smaller sized shrimp landed fresh and sold to the industry for further processing. The boiled *Pandalus* landings are cooked onboard before landed. Since the shrimp loses weight when boiled, these landings must be raised by a factor of 1.13 to obtain fresh weight for the landings statistics.

The TACs are limiting the Swedish *Pandalus* fishery and in order to distribute landings over the year the fishers have voluntarily introduced rations per fisher per week. This has resulted in high-grading of the catch, increasing the discarding of less valuable smaller *Pandalus* to increase the proportion of the more valuable boiled shrimp in the individual landings ration.

4.2 Landings, catch and effort data

4.2.1 Landings

Landings are given in Table 4.1 by area (Division IIIa and Sub-area IV) as officially reported to ICES. In Skagerrak the landings for 2003 increased approximately 10% compared to 2002. It was only in the Danish fishery the recorded landings increased. In Sub-area IV total landings have increased only slightly, due to increased Norwegian landings in 2003. The combined total landings from IIIa and IV were 8% higher in 2003 than in 2002.

Table 4.2 presents the landings and estimated discards for the assessment unit 'Skagerrak and the Norwegian Deeps' i.e. Div. IIIa and the eastern part of Div. IVa. The landings in 2003 were around 13 000 t, an increase of 1000 t compared to landings in 2002. Some errors and misprints in the landing figures for earlier years were corrected.

Landings from Norway and Sweden (and to a very small extent from Denmark) consist of a fraction of larger shrimp that are boiled on board and a remaining portion of smaller shrimp landed fresh. The boiling causes the shrimp to loose weight. The conversion factor to obtain live weight is 1.15. Official reported figures from Norway are given as landed weight. Sweden has adopted the same procedure for the last few years. In the amounts used by Working Group, the Swedish landings of large shrimp have, however, always been converted to live weight. The amount added for 2003 was 145 tonnes. The Working Group has applied no conversion on the Norwegian landings. The underestimate of total landings by this omission was for 2000 roughly estimated to about 300 ton. The Working Group felt that this estimate was too inaccurate to include in the assessment figures. When more reliable data for estimations become available, the landings for all years should be updated.

4.2.2 Discards

In the Norwegian and Swedish fisheries one may distinguish two categories of discarded shrimp:

The smallest size fractions from the grading procedure are not accepted by the canning industry and are discarded. This practice is traditional in the Norwegian and Swedish fisheries. This is probably also the case for the Danish catches. The Working Group estimated the amounts of discards by using the Norwegian length measurements from samples taken onboard before discarding. The proportions below 15-mm carapace length are considered to be discarded. The estimated amount for 2002 was 254 t. Since these Norwegian data were not available for 2003, no such estimate is presented for 2003. However, it is likely that the amount of discards has been much higher in recent years than suggested in Table 4.2.2.

Quota restrictions and the substantial price difference between large, boiled shrimp and medium sized fresh ones together with a voluntary system of weekly rations (different for medium and large shrimp) have resulted in high grading by discarding the medium sized ones. In recent years several Danish shrimp vessels landing boiled shrimp in Sweden have probably been following this practice. The amounts of discards in this category in the Norwegian and Swedish fisheries were in an earlier report estimated for 1996 and 1997 only. The estimation was based on separate quarterly length distributions for the categories large and medium sized and the selection ogive for the sieve. The total annual amount of this type of discards could be more than 1000 tons. However, at present such estimates are considered too inaccurate to be included in assessments, but the working group expects that better data on discards will available through the current EU funded discard sampling programmes. According to qualitative information from the Danish fishing industry, the amounts of discarded shrimp in the Danish *Pandalus* fishery are rather small.

4.2.3 Effort data

Annual national figures for landings per unit of effort (LPUE) and estimated effort are shown in Table 4.3 and Fig. 4.1. Total national effort values have been estimated from LPUE data based on logbook records. The Danish and Swedish LPUE in 2003 was on the same level as in 2002, whereas the Norwegian LPUE seems to have increased. However, according to information from the Danish fishing industry the majority of the Danish shrimp trawlers have been equipped with twin trawls during the last 10 years period increasing the efficiency of vessels. The EU logbooks do not give information on the number of trawls used, and quantitative information on the development in the Danish fishery is not available yet, but it is likely that the trend of the recorded Danish LPUE figures during the last 10 years is biased to some extent, and that the real LPUE is overestimated and therefore the total effort may be underestimated. It is recommended that the qualitative information on the development of the Danish shrimp trawls be quantified in order to obtain more realistic estimates of LPUEs. The Swedish shrimp trawls are still mainly single trawls. Here it was pointed out that the discarding due to high grading, the Swedish LPUE figures may be underestimates. No information on the development in the Norwegian shrimp gear for Skagerrak and the Norwegian Deeps was available.

In order to obtain the same effort unit for all 3 countries, i.e. 'fishing hours', the Danish unit 'fishing days' was transformed to 'hours' on basis of functional regressions between Danish-Norwegian and Danish-Swedish LPUE. These two regression coefficients were averaged to get Danish kg/hr as well as the total Danish effort in hours (unit=1000 hours). The missing Norwegian data from 1984-85 were estimated by functional regression Norway-Sweden and the factor 1.12 applied. The estimated time series of total international effort (Khrs) and LPUE (Kg/hr) are shown in Table 4.4 and Fig. 4.2

4.3 Sampling of Landings

4.3.1 Sampling frequency, intensity

National sampling effort is presented in table 4.5. The overall sampling level 2003 was around 15 kg per 1000 ton landed or 2500 specimen. Variations in the intensities between countries and between seasons indicate that improvements could be made.

4.3.2 Catch in numbers at age

The length data are pooled by quarter, and these national quarterly length distributions have then been partitioned into age compositions by the Bhattacharya method (software: FISAT). As in previous years the mean lengths by age group are used as a check of the consistency of the estimates, see Figure 4.1. Due to lack of Norwegian length data for 2003 the Norwegian total landings were age distributed according to the combined Danish and Swedish age data.

Table 4.6 gives the "catch-at-age" data. While previous years' tables also tabulated landings at age, this year's tables have included discarded 0 and I-Group shrimp. Catches are dominated by shrimp of ages 1 and 2. It is seen that in 2003 there seems to be shift towards younger ages in the stock. The numbers of age 3 and older are likely to be underestimates, due to the way the Bhattacharya method operates. In general, the WG doubts the reliability of estimates of the older age groups, i.e. those > age 3. This doubt is also reflected in the pooling of ages >3 in to a 'plus-group' in the XSAs performed in previous years.

4.3.3 Mean weights at age

Weights-at-age for the Danish catches were derived from the length samples of the catches, where the weights of the measured shrimp in each sample are recorded by length group. The corresponding Norwegian and Swedish weights-at-age figures are based on quarterly length-weight relationships obtained from the Swedish length samples in which all shrimp are weighted individually. The mean weights-at-age in the catch is given in Table 4.7. In some years there were no records 0-group shrimp in the catches, then averages for the other years were used. The same procedure was applied for the +group (+gp) in 2003.

4.3.4 Estimation of SSB, maturity ogives

In the estimation of SSB for the *Pandalus* stocks in the North Sea area the 0- and 1-groups are assumed to be immature, and age group 3and older groups are fully mature. In the cohort based assessments (XSA) the mature part of the 2-group or potential spawners was taken as the sum of intersexes and females in the first quarter of the year.

These proportions were:

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0.62	0.09	0.20	0.26	0.82	0.96	0.73	0.59	0.45	0.70	0.51	0.58	0.51	0.60	0.65	0.76	0.51	0.52

This method was not appropriate in connection with the SPP model, where stock size estimates were based on survey data from October-November. At the time of the survey it is assumed, that the spawning stock consists of the females in the stock. Thus to get estimates of SSB the proportion of females (by weight) in the survey catch was calculated. These proportions varied between 56 and 74%. They were then applied on the estimates of average biomass, $(B_y + B_{y+1})/2$.

Since no assessment was made this year, no update of the maturity data has been presented. The WG recommends, that in future assessments the procedures for estimating SSB be standardised for all *Pandalus* stocks in the North Atlantic.

4.4 Trawl survey data

4.4.1 The Norwegian trawl survey

The Norwegian trawl survey for shrimp in the Skagerrak-Norwegian Deep area has been conducted during six weeks in October-November from 1984 to 2003. However in the two recent years, 2003 and 2004, significant changes have taken place. The R/V 'Michael Sars' used from 1984 to 2002 was taken out of service in 2003 and replaced by R/V 'Haakon Mosby' for the survey in 2003. This vessel, at that time, had winches that were too small to haul the standard Campelen survey trawl and a different trawl was used. In 2004 the R/V 'Haakon Mosby' had the winches from R/V 'Michael Sars' installed. The survey period was, however, shifted to May for several reasons – the most important was availability of vessel due to removal of R/V 'Michael Sars' from the fleet.

The survey area is divided into 16 strata: from 100-200m (stratum 1,3,5,8,11 and 14), 200-300m (stratum 2,4,6,9,12 and 15) and 300-500m (stratum 7,10,13 and 16), see Fig. 4.4. The trawl hauls are spread evenly over the area covering the depths mainly between 100 m and 450 m depth. On the southern and eastern part of the Deeps it is possible to trawl almost everywhere, whereas along the Norwegian coast the areas suitable for trawling are restricted. For most of the trawl hauls the same positions are used all years. The gear used, except for 2003, is a "Campelen 1800# x 35mm" shrimp trawl, which is the standard demersal sampling trawl of Norwegian research vessels. A rubber-wheel gear was used until 1989 when a rockhopper gear was mounted on the same trawl. The opening of the trawl is app. 4.5m and the wingspread is app. 15m. During shrimp surveys a 6 mm mesh-size lining net in the cod end is used whereas the meshes in the rest of the cod-end is 22mm.

In 2003 an Åkra Shrimp trawl 1420# x 40mm was used, having a 7.5m opening height and a wingspread of app. 20m. The mesh size in the cod end is 42mm, although an inner lining net was used.

The duration of the trawl hauls was 1 hour until 1989, since then 0.5 hour hauls have been the practice. It is assumed to be of great importance that the same vessel, fishing-gear and time of year be used in order to obtain the best abundance estimates. However, these will also be influenced by annual variation in temperature and other environmental conditions. Especially the 0-group has through time proved to be unreliable as a measure of year class strength as temperature influence growth and vertical distribution.

In 2004 the survey was undertaken in May. However, it is strongly recommended that the future surveys be conducted in the 1 quarter in order get good estimates of the 1 group as recruits and good estimates of SSB (berried females). Together with the odd trawl in 2003 the time series is at present suffering a severe "hole" or "break" that may cause problems in the assessment, now and in the future. It is therefore recommended that calibration experiments are conducted to obtain correction factors for shrimp and fish (weight and length distributions).

In this connection the WG wishes to stress this year's problems with the lack of crucial Norwegian assessment data. When WG letters specifying data requirements have been sent well in advance to all WG members, one would expect response from all active members providing a major part of the necessary data input, especially when significant changes in time series have taken place since the last assessment meeting

4.4.2 Analysis of Survey Data

4.4.2.1 Shrimp: Swept area estimates of numbers-at-age

The width of the trawl opening, used for calculating swept area estimates, is 11.7m. (Teigsmark & Øynes, 1983). The average speed is 3 nm/hour and thus the trawl covers 0.019 nm2 in 1 hour. The total number of shrimp caught per hour is calculated for each trawl haul. Total number of shrimp in a stratum is calculated as average number of shrimp per hour by stratum, divided by 0.019 and multiplied by the area of the stratum.

Samples of 250-300 specimens are taken from each trawl haul. The shrimp are measured (CL) to the nearest mm below. Weighted average length frequencies for each stratum are calculated with catches per hour in the trawl hauls used as weights. This length distribution is then split into age groups by the Bhattacharya method. The output is number of shrimp by stratum and age group. These figures are considered as indices only, since a proportion of the shrimp is pelagic and not available to bottom trawl. This is especially the case for the 0-group (Table 4.8).

4.4.2.2 Shrimp: Swept area estimates of total biomass

Total weight of shrimp caught per hour is calculated for each trawl haul. Total weight of shrimp in a stratum is calculated as average catch of shrimp per hour by stratum, divided by 0.019 and multiplied by the area of the stratum. The output is weight of shrimp "available to trawl" by stratum (Table 4.9).

In order to get an estimate of total biomass in the surveyed area, a value for the catch efficiency (= catchability coefficient) of the trawl is needed. The only "estimate" of the efficiency of the "Campelen 1800" trawl that is available is the 11.7m "efficient" wing spread used in the swept area calculations. To obtain a better estimate of the total biomass the WG therefore has also applied, as a first approximation, an additional value of 0.2 for catch efficiency. This value is based on the work of Berenboim et al., 1980. These authors describe photogrammetric investigations in the Barents Sea where shrimp density (numbers per square meter) were measured. It was found that a 'catch efficiency' of 0.173 gave abundance estimates corresponding to the photo survey. Applying a catch efficiency of 0.2 on the estimated figures for biomass "available to trawl" given in Table 4.9 estimates of total biomass in the area are obtained (see Table 4.15).

4.4.2.3 Fish: Catches per nautical mile

The fish in the hauls were measured and weighed by species. Biomass by species and nautical mile trawled was calculated by haul and averaged over all hauls. This procedure is used, because the database is designed to provide fish data by statistical rectangles and not by the 16 strata as for shrimp. (Table 4.11.)

4.5 Assessment of the ***Pandalus*** stock in Divisons IIIa and IVa East.

4.5.1 Background / history

The *Pandalus* stock in Div. IIIa and IVa East was assessed by cohort analyses (VPA/XSA) from 1987 to 2000. The input was age disaggregated catch data (Tables 4.6 & 4.7). Commercial CPUE at age was used for tuning in the earlier assessments. Later stock indices at age from the Norwegian shrimp surveys were used.

The XSAs were characterised by non-favourable diagnostics (see Sect 4.6 in ICES 2002/ACFM:04) and consequently by poor estimates of fishing mortality (F) and stock size (N). Several features characteristic to the shrimp stocks reduce the applicability of the XSA:

- Few age groups in the stock.
- Large uncertainties in the ageing of especially the older age groups.
- A variable natural mortality exceeding the fishing mortality.

An additional cause could be that the assumption of the Fladen stock being independent of the IIIa stock is wrong, cf. Sect. 3. The available age disaggregated data seem not, however, to fit the XSA model very well.

A connected problem has been the treatment of natural mortality. Even if natural mortality is likely to be variable owing to the high suitability of shrimp as prey item for many fish species, it was assumed constant at 0.75 in most of the assessments until 1999.

The WG attempted in its assessment 1999 - 2001 to include predator dynamics by letting the M values vary according to the total SSB of roundfish in the North Sea (sum of cod, haddock, whiting and saithe), and /or the weight of likely predator species caught in the Norwegian shrimp surveys. In want of better estimates of the likely level of predation these indices were scaled to give an average M of 0.75 over the time span of the assessment. However, this treatment of the predation resulted only in minor changes in the perception of shrimp biomass dynamics (Figure 3.3 in ICES, 2000).

In 2000 and 2001 several of the main input components to the assessment were subject to critical discussion and revisions in order to improve the assessment. A new assessment approach was introduced by applying a stock production model including a predator component. In this model (described below) predator components have been included in the assessment of Divisions IIIa and East stock. This model, which is described below, has been applied for the assessment of this stock, 2001-2003. *However, due to the break in the time series of the Norwegian trawl survey in Skagerrak and the Norwegian Deeps in 2003 consistent input data was not available to the 2004 WG. Furthermore, the WG also has taken notice of the problems and criticism of the simple SPP model used:*

- *The real level of biomass cannot be determined by the model, but has to be set by some catchability factor. However, no such factor is available for the Campelen 1800 survey trawl.*
- *The age 1 index is proportional to the bulk of the commercial catch and a dominant part of the survey index, and is thereby not an independent index of recruitment.*
- *The use of this simple production model is not suited with the available data without having growth and mortality parameters for the stock.*
- *The model is not very sensitive to the input figures, which then must be realistic to avoid the model to end up with unrealistic 'local' minima in the least square estimates.*

The WG decided to leave last years SPP assessment in the report as background documentation for elucidation of the problems and for future improvements of the assessment.

4.5.2 Stock Production Model applied in the 2003 assessment

4.5.2.1 Description

For the assessments 2001-2003 the Working Group applied a model based on aggregated data. The model has been described and exemplified by Stefánsson et al. (1994). It is a stock production model (referred to here as SPP), which includes the effect of yearly recruitment and predation. Similar models have been described and evaluated by Cadrin (2000.)

The model is expressed as:

$B_{t+1} = aB_t - C_t + bR_t - pD_t$

$\hat{U}_t = q(B_t + B_{t+1})/2$

Where

B_t - (fishable) biomass of shrimp in year t

C_t - yearly catches

R_t - yearly recruitment indices

D_t - yearly index of predator biomass

U_t and $\hat{U}_t$ are the reported and predicted biomass indices.

The parameters of the model (B_0, a, b, p and q) are estimated by a least-squares fit (performed by the Excel Solver). The expression to minimise is the sum of squared differences between observed and predicted biomass indices:

$\Sigma(U_t - \hat{U}_t)^2$

The model was modified by changing the way biomass indices were calculated. In the original model yearly commercial CPUE were used as indices, these were related to the average biomass at the beginning and end of each year. The survey indices used here are related to the beginning of the year, thus:

$\hat{U}_t = qB_t$.

4.5.2.2 Input Data for the 2003 assessment

The input data cover the period 1984 to 2002 and consisted of:

Yearly catches for this stock, see Table 4.12 and cf. Table 4.2.

Biomass indices from the Norwegian bottom trawl surveys in October raised to total area surveyed and expressed as thousand tonnes. Data points were moved forwards from November to 1 January. Strata 1,3,and 8 were omitted due to sporadic coverage by trawl hauls. From these total biomass values the weight of the 0 and 1-group were subtracted, see Table 4.10.

Recruitment indices. The weight in ton (numbers * average weight) of 1-group shrimp raised to total area surveyed in the Norwegian Surveys. The number of 1-group shrimp was estimated by the Bhattacharya method (Table 4.10).

Indices of predation. The total weight of likely predator species (22 species) caught per nautical mile in the Norwegian trawl surveys in Skagerrak and NE North Sea was chosen. The dominating species in this assembly are Blue whiting (≥30 cm), Saithe, Cod and Roundnose Grenadier. The species included were those that are known to consume *Pandalus* (Albert, 1993, 1994a,b, Bergstad 1991, Skjaeraasen 1998, Torres, Roderiguez-Marin and Loureiro 2000) (Table 4.11).

Note that the indices here refer to the estimated biomass "available to the trawl" in the survey. The survey estimates of 0-group in the 4th quarter were not considered useful as recruitment indices because of the varying ability of the trawl to catch them. The size (7-12 mm CL) of 0-group shrimp is normally within the selection range of the gear, but both size and vertical distribution are depending on the temperature and vary between years.

Catches, recruitment indices and predator indices are presented in Table 4.12.

4.5.2.3 Results (2003 assessment)

Estimates of parameters values and the corresponding Sum of Squared differences (SSE) are given below.

a	0.99
b	5695
p	667
q	0.00012
B_0	90 000
SSE	195

Estimated shrimp biomass and amount consumed by predators are given in Table 4.13 together with the observed and calculated biomass indices.

The relation between observed and estimated biomass indices is also illustrated in Figure 4.5. The regression indicates that 42% of the variation in biomass indices could be explained by the model.

Exploitation expressed as Yield/Biomass has fluctuated between 8,6 and 19,9 % with an average of 13,9% (Table 4.14). Estimated predation mortality (Consumption/Biomass) has varied between 16,8% and 46,6% with an average of 30,7%.

4.5.2.4 Establishment of biomass level (2003 assessment)

The model is not very sensitive for the chosen starting value of B_0 (Stefánsson et al. 1994, ICES 2001). This was illustrated in Fig. 4.3 in the Working Group report from 2001 (ICES, 2001), which gives the SSE as a function of the B_0 value.

The actual level of B_0 was chosen on basis of a comparison with the estimate of total biomass in the Surveys using swept area and the chosen value of catch efficiency (ICES 2003). The Survey estimates and biomass estimated from the model with B_0 90 000 ton is given in Table 4.15.

4.5.2.5 Evaluation (2003 assessment)

4.5.2.5.1 Comparisons with Model Output and Commercial Fleet Data

LPUE – Biomass Indices

The estimated international LPUE values were compared with biomass estimates from the SPP and with the survey indices (Fig. 4.6). For the early years of the period the correlation between LPUE and model biomass is not very convincing. The correlation coefficient is 0.5.

Effort – Y/B

A comparison between estimated international effort and Y/B (as a proxy for fishing mortality) is shown in Fig. 4.7. Here B is the 'average' biomass', ($B_y + B_{y+1}$)/2. Both series give the same general trend; the correlation coefficient is 0.53.

4.5.3 State of stock in 2004 and 2005.

No update assessment was made this year. However, the WG considered the available, most recent, indicators of stock biomass:

1) The trend in commercial LPUEs presented in tables 4.3 & 4.4 And Figs 4.1 & 4.2 as indicator of the development of the stock up to 2004: The combined LPUEs (Fig. 4.2) show an increasing long term trend from 1989 to a peak in 1997-8, declined again in 1999 to 2001 and increased in the recent two years and LPUE in 2003 is the highest observed during the period of available data. The combined effort shows a decreasing long term trend. The similar pattern in LPUE between the three countries might indicate that the exploitable stock biomass has followed the same pattern, i.e. increased until 1998, decreased in 1999 to 2001 and increased again in recent two years. The recorded increases in LPUE may also reflect increased fishing power of the shrimp vessels as stated in Sect. 4.2.3, where it is suggested that a shift to twin trawls could explain some of the increase in Danish LPUE.

2) The biomass index provided by the Norwegian survey in May 2004 compared to the indices up to 2002: Even if the swept area estimate of shrimp biomass for 2004 (Table 4.9) is not directly comparable with the estimates up to 2002, because of change of survey time, the 2004 figure certainly confirms that the stock seems to be stable.

Because the Norwegian survey index for 2004 indicates a stable stock it is the view of the WG, that the above mentioned trends in LPUEs (as biomass indicators) also reflect a stable stock.

From these considerations the WG concludes, that the *Pandalus* stock in the IIIa and IVa East area does not show signs of overexploitation. Also based on these considerations it is the opinion of the WG, that the stock is stable and will remain at the same level in 2004 and 2005 as in recent years.

On this basis the WG recommends, that the total landings from IIIa and IVa East in the coming years be maintained at a status quo level of around 15000 t.

4.5.4 Biological Reference Points

The view of the WG is that, the data on the stock-recruitment relationship, from previous assessments, did not support establishment of a SSB reference value for this *Pandalus* stock based on this relationship (ICES 2003). In 1998

ICES (ACFM, 1998) pointed out that there was not basis for establishment of a $\mathbf{B}_{\mathrm{lim}}$ on basis of the available S-R data at that time. Considering the major impact from predation, such a poor relationship is likely.

According to previous assessments, predation accounts for at least twice as much removal of the *Pandalus* stock than the fishery in the entire assessment period. Such dynamics also render it problematic to establish a reference value for F (or Y/B), at least if the relative magnitudes of F and M (predation) are independent of stock size.

It is the opinion of the WG, that until progress is made in elucidating the SSB-R relationship as well as the F-M relationship, the best and simplest approach would be so set SSB reference values based on the some lowest "observed" (estimated) values of SSB. However, in the case of the *Pandalus* stocks in the North Sea areas such limit reference values, for instance as $\mathbf{B}_{\mathrm{pa}}$, could only be used in harvest control schemes when more is known on the predation. Until then they would serve as limit values triggering warning signals. At present, the magnitude of the stock is uncertain, but in this connection the WG notes that for data poor situations, where survey indices are applied as stock indicators it has been suggested that a decline of 85% from the highest observed index could be used as a proxy for $\mathbf{B}_{\mathrm{lim}}$ (NAFO SCS Doc. 04/12).

The WG also notes that on Fladen Ground the *Pandalus* stock was seemingly depleted in 1988 after very high catches in 1987 (ICES, 1990). However already in 1989 the stock had recovered without any management regulations of the fisheries. This indicates that for shortlived species like *Pandalus* other factors than fishery must have major influence on stock development.

5 The *Pandalus* Stock on Fladen Ground (Division IVa)

5.1 Catch and Effort

Table 5.1 shows the landings from the Fladen Ground since 1972. Since 1991 total landings have fluctuated between a low of around 500 tonnes to a high of more than 5000 tonnes. Mainly the Danish and Scottish fisheries exploit the shrimp on Fladen. Denmark accounts for the majority of landings. Note that since 1999 total Fladen landings, like landings in IIIa and IVa East, have been on a lower level than in the previous 4 years period. The recent landings have only been around 1/3 of the level of 1995-98 landings. Landings in 2002 declined further compared to the landings in 2001. No U.K (Scottish) fisheries on Fladen Ground directed for *Pandalus* took place in 2001, 2002 or 2003. In general, the shrimp fisheries on Fladen take place mainly during the first half of the year, mainly in the second quarter.

Total effort for the Danish and Scottish Fladen fisheries is estimated from logbook based LPUE data from these fisheries. Table 5.2 gives these effort data. In 2003 the Danish LPUE was at the same level as in 2002.Estimated total Danish effort decreased slightly due to a decline in landings. No effort data for 2001, 2002 and 2003 were reported from U.K. In order to combine Danish and Scottish effort data in the earlier years, relative effort indices have been calculated for each country. The combined effort indices have been weighted with the landings. Both LPUE and total effort has been at rather low levels in recent years compared to the higher levels in 1995, 1996 1998.

5.2 Previous Assessments

The shrimp stock on Fladen has not been assessed since 1992, due to incomplete age data and the lack of separate, fishery independent data. Thus the most recent analytical assessment of this stock was presented in the 1992 Working Group Report (ICES, 1992).

However, some data for analytical assessments for later years have been compiled at the national laboratories (Denmark and Scotland) and are available to the Working Group. However, due to the frequent large fluctuations in the Fladen fishery, samples for length composition of the catches do not always cover the entire year.

Catches from Fladen consist mainly of two age groups. During the first two quarters of the year age groups 2 and 3 normally dominate the catches. During the 4$^{\mathrm{th}}$ quarter age group 3 usually disappears from the catches, while age group

1 adds to the catches. Lack of information on recruitment from surveys in this area has prevented the Working Group from making stock predictions for the Fladen.

6 The *Pandalus* Stock in Farn Deeps (Division IVb)

Sine 1991, only UK vessels have fished *Pandalus* in the Farn Deeps. Total landings fell from 500 t in 1988 to none in 1993. In 1995 and 1996 again about 100 ton were reported. There have been no reported landings from the Farn Deeps in recent years, see Table 6.1.

7 The *Pandalus* Stock in the Barents Sea and Svalbard area

7.1 Description of the fisheries and their development in recent years

Norwegian vessels began to exploit the shrimp fisheries in the Barents Sea and Svalbard area in 1970. Russian vessels entered the shrimp fishery in 1974. The catches increased continuously until 1984 when the total catch reached a maximum of 128,000 t. By that time vessels from other countries had entered the fishery. Since then, biomass and catch levels have fluctuated because there were different recruitments, cod consumption and effort in the fisheries due to price of shrimp. The catch peaked above 80,000t in 1990 and in 2000. The most important fishing ground is the Hopen area in the central Barents Sea.

The first vessels using double trawls entered the fishery in 1996. Since then the effort has increased continuously and in 2002 approximately 35 Norwegian vessels had the technology to use double trawl or even triple trawl. Since 2002 the majority of the catch is caught by double trawl.

In the Svalbard area the shrimp fisheries are regulated by number of effective fishing days and number of vessels by country. In the Barents Sea and Svalbard area, Norwegian rules are that the fisheries be regulated by fishing licences and by smallest allowable shrimp size (maximum 10% of catch weight may be < 15 mm carapace length, CL). However, the regulation by smallest allowable shrimp size is not considered to be an efficient management tool in the REZ (Bakanev and Berenboim WD1, Annex 1). In the Russian Economic Zone, a TAC is established each year by Russian authorities. Fishing grounds are closed if by-catch limits given as number of individuals in 10 kg of shrimp are exceeded. In 2004 and 2005 the values of allowed by-catch are set at eight for the sum of cod and haddock, ten for redfish and three for Greenland halibut per catch of 10 kg shrimp.

Sorting grids in the shrimp trawls first became mandatory operating within the Norwegian 12 miles zone in February 1990. In October 1991 this directive was extended to apply to shrimp trawls used in all of the Norwegian EEZ. Finally, in 1993 the Joint Norwegian Russian Fisheries Commission agreed that the sorting grid was to be mandatory for all vessels conducting shrimp fishery in the Barents Sea and the Svalbard area.

7.2 Landings

Preliminary reported landings for all countries show a substantial decrease of landings from 82,816t in 2000 to approximately 60,000t in 2002 and 2001 and a further decrease to 40,000t in 2003 (Table 7.1, Figure 7.1). Thereby the total landings have decreased to 50% in three years.

7.3 Discards

Since there is no TAC in the Barents Sea all catches are landed and it is believed that there are no discards of shrimp in the area. However, it is recommended that data on discards of small shrimp in the Barents Sea and Svalbard will be presented in 2005.

7.4 Effort and CPUE

Catch, effort, and annual CPUE series for Norway and Russia are presented in Table 7.2. The CPUE series for both countries are given in Figure 7.2. The Norwegian shrimp fleet has since late 1990s been upgraded both concerning vessels and the use of double and triple trawls. In the logbooks the use of these trawl types have been difficult to register and to make available for further use. Here revised series of catch per unit of effort (new CPUE) and new effort have been given for Norway, standardised as vessels 1000-1500 hp with single trawls. However, this standardisation does not seem to correct for all advancement in shrimp trawl technology. The Norwegian data show a peak in the effort in 2000 at the same level as the earlier peaks in 1985 and 1990. The Russian and Norwegian effort decreased in 2001 with a slight increase in 2002 followed by a further decrease in 2003. The CPUE of the Russian fleet (vessels<1300hp) has fluctuated in accordance with the shrimp biomass (Berenboim *et al.* 2001). It should be noted that the Russian fleet is also under development.

7.5 Sampling of landings

In 2002 and 2003 observers collected samples on board commercial Spanish vessels in the Svalbard zone (Casas Annex 2 WD 2). Length and sex distribution data and data on by-catch of young fish were recorded. These data show a reduction of females from 33% in 2002 to 18% in 2003.

Monitoring of the shrimp catches is required due to the regulation protecting juvenile fish and shrimp through area closures. The Directorate of Fisheries in Norway has, during surveillance cruises conducted by commercial shrimp trawlers, collected data on length distributions in the shrimp catch since 1995. The Norwegian Coast Guard also samples some length data during inspections of shrimp catches. In 2002 the Institute of Marine Research established a reference fleet where fishermen take samples of the catch. One of the vessels included in the reference fleet is a part time shrimp trawler. The carapace length is measured on 300 individuals of shrimp in each sample. The number of samples collected has increased from 70 samples in 1999 to 210 samples in 2003. The sampling frequency will be further increased by more inspections conducted by the Coast Guard.

The catch was in 2000 dominated by shrimp aged four and five years (Figure 7.3). The catch pattern moved towards three year olds in 2001. The catches in 2003 were again dominated by four year old shrimp of the 1999 year class.

7.6 Research Vessel Data

7.6.1 Trawl Surveys

In the Barents Sea and the Svalbard area, standard shrimp surveys have been conducted by Norway since 1982 and by Russia since 1984 (Figure 7.4.). However, during the 90's, both surveys have suffered from reductions in survey time. The Russian vessels did not survey the Svalbard area for many years but have carried out surveys in this area in 2001 and 2002. Unfortunately no shrimp cruise was conducted by Russia in 2003 and 2004. The amount of time available for the Norwegian survey has been reduced from 50 days to 27 days. Detailed information pertaining to the status of the stock is described in 1981–1991 Norwegian reports (Tavares and Øynes 1980, Teigsmark and Øynes 1981, 1982, 1983a, 1983b, Hylen *et al.* 1984, Tveranger and Øynes 1985, Hylen and Øynes 1986, Hylen *et al.* 1987, Hylen and Øynes 1988, Hylen *et al.* 1989, Hylen and Ågotnes 1990) and Russian reports (Berenboim *et al.* 1986, Berenboim *et al.* 1989, Berenboim *et al.* 1990, Mukhin and Sheveleva 1991). Annual joint Norwegian-Russian papers have been produced since 1991 (Berenboim *et al.* 1992, Aschan *et al.* 1993,1994, 1995, 1996). Since 1997 the status of the stock has been summarised in annual protocols of the Russian-Norwegian Comission and ICES (Anon. 2003). Additionally evaluations of the Norwegian surveys have been conducted (Aschan and Sunnanå 1997, Harbitz *et al.* 1998).

The Norwegian shrimp cruises are conducted with R/V "Jan Mayen" in April-May in the Barents Sea and in August-September in the Svalbard area. In both areas more than 100 stations were sampled. In the Barents Sea a regular grid placing the stations on a distance of 20 or 28 nautical miles, depending on shrimp density is used. In the Savlbard area the stations are also fixed but distributed within strata defined according to depth and latitude. The survey trawl is a Campelen with1800 meshes and has the following specifications; 30 m headline, 19 m ground rope and 80-42 mm knot to knot stretched mesh size in the body. The mesh size of the cod end has been stable with 42 mm knot to knot stretched mesh. In 1986 a 4 m inner net of 10 mm stretched mesh size was introduced, and this was replaced in 1994 with a 15 m inner net with 20 mm mesh. A small mesh-bag (8 mm) has been attached to the lower belly as standard equipment since 1995. The sample of small shrimp obtained in this bag gives an additional index of abundance of the smallest shrimp and provides data on the size of the youngest age groups.

Bridle arrangements have been constant at 40 m upper and lower bridles. A 24 m rope connecting the warps 80 m above the doors ("strapping") constrains the spread of the doors to 47 m, wing spread 14,5 meters and the vertical opening of the trawl to approx. 5 m; the chains are equipped with two steel bobbins (45.7 cm diameter) each, 40 floats (20 cm diameter) are attached to the fishing line, 15 floats are attached on each side along the belly, and the mid sections of the "Rockhopper" gear are changed from metal to rubber discs.

Three types of trawl doors have been used. In the 1980s Waco combination doors (1500 kg) were used. During the early 1990s traditional "Steinshamn" V10-doors (2050 kg) were used, and in 1994 these were replaced by "Steinshamn" W9-doors (2050 kg) with four point connections (Kristjansson, 1994). Thyborøn doors will probably be used in 2005 after an evaluation of results from parallel trawling.

In all Russian surveys, a commercial Russian shrimp trawl without sorting grid was used. The mesh size was 40 mm and a10m inner net with small-mesh (12 mm) was used. The horizontal opening of a trawl is 14.5 m, the vertical opening is 5 m. A trawling distance of 3 nautical miles was used and the trawling speed was 2.6-2.7 knots.

7.6.2 Analysis of Survey Data area

There is a strong correlation between the Norwegian and the Russian survey results (Figure 7.5). Biomass indices were highest during 1984, and have since fluctuated between 30% and 60% of this level (Tables 7.3. and 7.4.) with peaks in 1991 and 1998-1990 and low values below the long term mean in 1987-1988, 1994-1995 and 2001 to 2004. Norwegian bottom trawl surveys indicate a decrease in shrimp biomass in the Barents Sea and Svalbard of 29% from 2003 to 2004. Especially the important Hopen Deep (-50%) and the Thor Iversen Bank (-36%) area show an obvious reduction.

Swept area estimates of numbers-at-age

In order to obtain good length frequency distributions for age analyses, oblique carapace lengths (CL) (from the posterior margin of eyestalk to the posterior mid-dorsal edge) of approximately 300 individuals from each trawl station are measured to the nearest 0.01 mm with an electronic calliper (Mitutoyo, Japan). The data are saved in the database in intervals of 0.1 mm. Shrimp ageing is completed by modal analysis using MIX 3.0 (MacDonald and Pitcher 1979). Annual age determinations have been conducted for 15 areas in the Barents Sea and 7 areas in the Svalbard area since 1991 (Aschan 2001, Hansen and Aschan 2001).

Since the growth of shrimp varies in time and space, it is difficult to decide on a good recruitment index. An age-length key constructed from the Norwegian Barents sea survey has been used to define the number of 1, 2, 3 and 4 year old shrimp as well as the number of shrimp of five years or more in the whole Barents Sea (Table 7.5). A common procedure for dividing shrimp into age groups has been agreed upon. Since very few shrimp < 15 mm CL are caught in the trawl, the index for one year old shrimp is based on the number of shrimp caught in the mesh bag attached to the underbelly of the survey trawl. The recruitment index for one year old shrimp is still low and the number of two and three year old shrimp has reduced dramatically since 2003 (Table 7.5, Figure 7.6).

The biological development of shrimp is divided into several stages. Shrimp starts off as males (Stage 2) after the juvenile stage (Stage 1). Thereafter they reach intersex (Stage 3) before they develop into first time spawning females with headroe (Stage 4). When the females mate, the roe is moved under the abdomen (Stage 5) where the eggs stay until hatched (Stage 6). Some females then take a resting period (Stage 7), but the majority starts on a new cycle with headroe (Stage 8). The Russian and the Norwegian coding of the stages are given in Aschan *et al.* (1993). Analyses of data from the 90's suggest that shrimp in the southern Barents Sea (area A) grew quickly and changed sex at an age of four years, whereas shrimp in the central and northern Barents Sea grew slowly (areas B, C and E) and changed sex at an age of 5 years or greater (Aschan 2001). The number of egg producing females is calculated using the annual L_{50} in the Barents Sea. The number of egg carrying females (stage 5+), has declined since 2002 (Table 7.5, Figure 7.7).

7.6.3 Natural mortality and predation

Predation by cod is the main source of natural mortality. However, it should be noted that other fish species such as Greenland halibut (*Reinhardtius hippoglossoides*), long rough dab (*Hippoglossoides platessoides*), thorny skate (*Raja radiata*) and blue whiting (*Micromesistius poutassou*) also prey on shrimp (Dolgov 1997, Dolgova and Dolgov 1997. The methods used in estimating cod consumption are described by Bogstad and Mehl (1997), and dos Santos and Jobling (1995). In the Barents Sea, the annual consumption of shrimp was estimated to be above 280,000 t throughout the period 1994–2001 (Table 7.6, Figure 7.8). Shrimp consumption rates may, however, have been overestimated. As future shrimp assessments have to include cod as predator, it is important to identify and study possible problems with the cod consumption estimates.

7.7 Assessment of the *Pandalus* Stock in the Barents Sea

7.7.1 Background

The great plasticity in growth of shrimp and age at sex change, as well as a lack of biological data and length distributions from the catches, make it difficult to apply traditional analytical fishery assessment methods to the data. Therefore a spreadsheet performance report (Caddy 1999, Koeller *et al.* 2001) has been used to assess the available information (Table 7.7). Several models have been used in assessing shrimp in the Barents Sea and some of these are listed below: 1. Production models: Shaefer and Fox stock models and stock production model including predation (Stefánsson *et al.* 1994, Berenboim and Korzhev 1997). 2. Catch at age analysis (cohort models): Single species virtual population analysis (VPA) and multi species virtual population analysis (Sparre 1984, Bulgakova *et al.* 1995)).

7.7.2 Status of the Stock

The Russian CPUE (Table 7.2, Figure 7.2) and Norwegian survey indices (Table 7.3) both indicate a decrease in the shrimp stock from 2003 to 2004. The survey index of 2004 shows a reduction of 29% since 2003, and is now on the lowest level since 1987. The spawning stock number has been decreasing since 2002 (Figure 7.7). The recruitment of one year old shrimp has been low but stable over the last two years, and the three year old shrimp show a reduction since 2003 (Table 7.5 and Figure 7.6). As the cod stock is still on a high level, the natural mortality is believed to be high.

The strong 1999 and 2000 year classes did not contribute to the assumed increase in shrimp biomass in 2004. These originally strong year classes seem to have been a target for predators and the shrimp fishery as young shrimp (Figure 7.3).

As the recruitment to the fishery in 2004 is lower than in 2003, the stock is expected to remain at a low level in 2005. Preliminary records indicate a catch of approximately 37,000 t for 2004, and the stock does not seem to allow higher catches in 2005. The WG recommends, that catches should be maintained at the low current level, until an increase in biomass is detected.

7.7.3 Recommendations on further work

- It is highly recommended that the Russian shrimp survey time series is re-established. The lack of Russian survey data is considered a big problem when doing the assessment. It is impossible to evaluate the status of the stock in the Kola Coast and the Goose Bank areas.
- Scientists should evaluate the procedures used in estimating the shrimp consumed by cod;
- Length and sex data from commercial catches should be provided by all nations involved in the fishery;
- Data on discards of small shrimp in the Barents Sea and Svalbard are should be presented in 2005;
- Authorities should enforce the accurate completion of logbook data in Norway, especially the use of single, double and triple trawls;
- Work on developing and evaluating assessment methods should be continued;

- Catch and effort statistics should be delivered to the ICES by all countries involved in the shrimp fishery in the Barents Sea and the Svalbard area. Now only available Norwegian, Russian and Spanish data are available.

8 The by-catch in the *Pandalus* fisheries in the Subarea IV and Division IIIa

8.1 Available data

In recent years there has been increasing focus on mixed fisheries or fisheries, where species from stocks subject to recovery plans or under special surveillance. The fisheries for Pandalus in the North Sea area cannot be classified as mixed fisheries as for instance some of the fisheries for Nephrops. The current by-catch regulations in force for the gears used in the fisheries for Pandalus restrict the amounts of by-catch, but nevertheless are several valuable fish species, e.g. cod, anglerfish, taken and landed as by-catch. Since the Pandalus fisheries are classified as 'small mesh fisheries' for 'human consumption (h.c.) species' there has for a long time been concern on the by-catches in these fisheries, and the Pandalus WG has since the 1980s regularly compiled and presented relevant information on by-catch in the WG reports.

Tables 8.1 A - G give for the recent 10 years period the available Danish, Norwegian and Swedish data on by-catch of the main species in the *Pandalus* fisheries landed for h.c. In the some years quantities of Norway pout and Blue whiting have been specified. For all 3 countries the data are from log book records and are only recording landings, i.e. not the discarded by-catch. Both the Danish and Swedish log book records cover nearly all the recorded *Pandalus* landings. The Norwegian records for 2002 and 2003 also cover the total landings, while those prior to 2002 only cover approximately 33% of total landings.

These tables also give cod as well as total h.c. by-catch as the percentage of *Pandalus* landings. It is believed that these are better estimators than % of total catch, since log-book recordings probably not always are consistent in recordings of e.g. Norway pout and/or Blue whiting. In Skagerrak the percentages of landed total h.c. by-catch are similar for all 3 countries (excluding trawls with selective grids). Considering cod only, it is noted that the percentage is highest in the Danish fisheries. However, for the Norwegian log-book records it is likely that the rather low percentages of recorded cod is because some of the cod by-catch has not been specified as cod, but merely as unspecified h.c. by-catch. Note that for the Norwegian data the category 'other market fish' is very high compared to this category in the Danish and Swedish data. Note that the Danish by-catches from the Norwegian Deep are higher than the Norwegian. A minor fraction of the Swedish *Pandalus* fishery is conducted with trawls equipped with a selective grid, and judging from the logbook records of landings by this gear type, it seems to be very efficient in reducing by-catch, see Table 8.1 C and Sect. 8.3.

It cannot be ruled out, that some times in some areas by-catch of valuable species, for instance angler fish, cod and witch flounder is considered a positive contribution to the total landings from a fishing trip for *Pandalus*.

The current 'at-sea-sampling' programme has provided sporadic samples of discarded by-catch in the Danish and Swedish *Pandalus* fisheries. However, these data are presently considered to scanty to base any assessments of the amount of e.g. discarded cod on.

8.2 The magnitude of cod landings from the *Pandalus* fisheries.

The historic data given in Tables 8.1 A – G indicate minor fluctuations without any trends in the amount of cod as by-catch. They do not seem to follow the trend in the development of the cod stock in the North Sea and Skagerrak. However, the relative high by-catch figures of Saithe in recent years in contrast to low values for the first half of the 1990s (Denmark and Sweden) could reflect the increase in size of this stock.

These historic cod by-catch figures indicate for instance that in recent years the total of amount of cod landed by the *Pandalus* fisheries in the North Sea and IIIa by Denmark, Norway and Sweden has fluctuated around 300 t. Since the U.K. shrimp fishery on Fladen Ground has been small in recent years, the overall picture would not change by adding this component. The overall conclusion on the total annual landed by-catch of cod in the *Pandalus* fisheries in these areas is that it contributes less than 1 % of total annual landings of cod in the North Sea and Skagerrak. This amount could probably be reduced further, if the shrimp-trawls were equipped with selective grids, as described below.

8.3 Improved species selection in shrimp trawls equipped with selective grids.

The current legal minimum mesh size of 35 mm (stretched mesh) in shrimp (*Pandalus* sp.) trawls implies the catch of also other unwanted undersized fish species and a resulting increase in mortality due to discards. Experiments with species selective grids installed in the trawl started in Norway 1988, and the Nordmøre grid with 20 mm bar space is now mandatory in Norwegian *Pandalus* trawls in the Norwegian zone. Recent experiments on shrimp fishing grounds in the Norwegian Deeps have shown that the by-catch of cod, haddock, saithe and whiting is low when targeting shrimp at depths deeper than 240-250 meters, which are the common fishing depths in this area. Particularly juveniles of such species are absent in shrimp trawl catches in this fishing area. (Valdemarsen and Misund, 2003). Similar species selective shrimp trawls have been tested in the North Sea and the Skagerrak in an EU Study project by Denmark and Sweden (Madsen et al. 1998). The Swedish experimental fishing was performed both inshore and offshore with identical rigging as in the Norwegian legislation. The results shows that the total proportion of fish in the inshore catch was reduced by 85% when the Nordmøre grid was used and the remaining fish by-catch consisted almost solely of Norway pout. No significant loss of shrimp could be seen, but average catch of shrimp per trawling hour decreased by about 7% when using the grid. Even in the offshore fishery the by far largest by-catch was Norway pout, which also is the most difficult species to sort out because of its small size. All other fish species were sorted to 97%, and commercial fish species to 99% efficacy.

The conclusions from these studies are that an introduction of the equivalent grids in the shrimp trawl fishery will drastically reduce the by-catch of fish in general, and commercial fish species in particular and according to published results, a comparable selection efficacy is unlikely to be achieved using techniques that depend solely on mesh selection.

Detailed description of Nordic experiments with grids in shrimp trawls is found in (Anon., 1996) and an extensive reference list is presented in (ICES, 1998).

9 The by-catch in the *Pandalus* fisheries in the Barents Sea

Young Northeast Arctic cod, haddock, redfish and Greenland halibut are caught as by-catch in shrimp fisheries in the Barents Sea. The figures for the cod by-catch are based on commercial Norwegian commercial shrimp catch statistics, logbook data, surveys and surveillance data from 1983-2002 (Aijad *et al.* 2004).

Especially one and two year old cod are caught in the shrimp fishery due to overlapping distribution of shrimp and cod in the central area of the Barents Sea and around Svalbard. Cod by-catch in the shrimp fishery has been regulated by area closures since 1983 (Aschan, 1999; Aschan, 2000). Furthermore, a by-catch regulation of max. 3 juveniles of cod and haddock pr 10 kg of shrimp was introduced in 1983. However,with the introduction of the sorting grid in 1995 the number of cod and haddock allowed as by-catch increased to 10. The results show that the numbers of cod taken as by-catch varied between quarter and between years. Northeast Arctic cod by-catch rates in stay around 1% of the annual shrimp landing recent years (Table 9.1). There is a declining trend in cod by-catch from 1997-2002. This by-catch rate is not thought to have an essential impact on the recruitment of Northeast Arctic cod (Aijad *et al.* 2004). The weight and number of individuals of other by-catch species does not exceed the estimates for cod. However strong year classes of haddock may reach the same values as cod.

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Table 4.1 Nominal landings (tonnes) of Pandalus borealis in ICES Division IIIa and subarea IV as officially reported to ICES.

	Division IIIa				Sub-area IV					
Year	Denmark	Norway	Sweden †	Total	Denmark	Norway	Sweden	UK (Engl.)*	UK (Scotl.)*	Total
1970	757	982	2740	4479	3460	1107	0	14	100	4681
1971	834	1392	2906	5132	3572	1265	0	0	438	5275
1972	773	1123	2524	4420	2448	1216	0	692	187	4543
1973	716	1415	2130	4261	196	931	0	1021	163	2311
1974	475	1186	2003	3664	337	767	0	50	432	1586
1975	743	1463	1740	3946	1392	604	261	0	525	2782
1976	865	2541	2212	5618	1861	1051	136	186	2006	5240
1977	763	2167	1895	4825	782	960	124	265	1723	3854
1978	757	1841	1529	4127	1592	692	78	98	2044	4504
1979	973	2489	1752	5214	962	594	34	238	309	2137
1980	1679	3498	2121	7298	1273	1140	38	203	406	3060
1981	2593	3753	2210	8556	719	1435	31	1	341	2527
1982	2985	3877	1421	8283	1069	1545	92	0	354	3060
1983	1571	3722	988	6281	5724	1657	112	65	1836	9394
1984	1717	3509	933	6159	4638	1274	120	277	25	6334
1985	4105	4772	1474	10351	4582	1785	128	415	1347	8257
1986	4102	4811	1357	10270	4288	1681	157	458	358	6942
1987	3466	5198	1085	9749	9642	3145	252	526	774	14339
1988	2246	3047	1075	6368	2656	4614	220	489	109	8107
1989	2527	3156	1304	6987	3298	3418	122	364	579	7802
1990	2277	3006	1471	6754	2080	3146	137	305	365	6084
1991	3258	3441	1747	8446	747	2715	161	130	54	3807
1992	3293	4257	2057	9607	1880	2945	147	69	116	5157
1993	2451	4089	2133	8673	1985	3449	167	29	516	6146
1994	2001	4388	2553	8942	1362	2426	176	41	35	4040
1995	2421	5181	2512	10114	4698	2879	166	217	1324	9284
1996	3664	5143	1985	10792	4063	2772	82	97	1899	8913
1997	3617	5460	2281	11358	3314	3112	316	52	365	7159
1998	2933	6519	2086	11538	3297	3092	187	55	1364	7995
1999	1398	3987	2114	7499	1679	2761	182	46	479	5147
2000	1898	3556	1890	7344	1956	2562	184	0	378	5080
2001	1186	2959	1958	6103	2030	3952	154	0	465	6601
2002	1967	3709	2044	7720	1647	3612	143	0	70	5472
2003	2612	3736	2098	8446	1631	3979	144	0	0	5754

* Includes small amounts of other Pandalid shrimp
† 1970 to 1974 includes subarea IV.
Total 1988 - 1990 includes19, 21 and 51 t. by the Netherlands
Note: 2003 figures are preliminary.

Tabel 4.2 Pandalus borealis landings from divisions IIIa (Skagerrak) and IVa (eastern part). as estimated by the Working Group

Year	Denmark	Norway	Sweden	Total	Estimated discards	TAC	Catch
1970	1102	1729	2742	5573			
1971	1190	2486	2906	6582			
1972	1017	2477	2524	6018			
1973	755	2333	2130	5218			
1974	530	1809	2003	4342			
1975	817	2339	2003	5159			
1976	1204	3348	2529	7081			
1977	1120	3004	2019	6143			
1978	1459	2440	1609	5508			
1979	1062	3040	1787	5889			
1980	1678	4562	2159	8399			
1981	2593	5183	2241	10017			
1982	3766	5042	1450	10258			
1983	1567	5361	1136	8064			
1984	1800	4783	1022	7605	*200*		7805
1985	4498	6646	1571	12715	558		13273
1986	4866	6490	1463	12819	414		13233
1987	4488	8343	1322	14153	723		14876
1988	3240	7661	1278	12179	750		12929
1989	3242	6411	1433	11086	1107		12193
1990	2479	6108	1608	10195	1226		11421
1991	3583	6119	1908	11610	497		12107
1992	3725	7136	2154	13015	541	15000	13556
1993	2915	7371	2300	12586	889	15000	13475
1994	2134	6813	2601	11548	214	18000	11761
1995	2460	8095	2882	13437	275	16000	13713
1996	3868	7878	2371	14117	318	15000	14436
1997	3909	8565	2597	15071	1039	15000	16110
1998	3330	9606	2469	15406	348	18800	15753
1999	2072	6739	2445	11256	639	18800	11895
2000	2371	6118	2225	10714	687	13000	11401
2001	1953	6895	2108	10956	701	14500	11657
2002	2466	7321	2301	12088	254	14500	12342
2003	3244	7715	2389	13348	*)		13348 *)

*) previous years' estimates of discards were based on Swedish samples and Norweigian survey data.
The change in the Norwegian survey gear ion 2003 has made it impossible to use Norwegian data for estimates, see Sect. 4.2.2

Table 4.3 National LPUE and total effort as estimated by the Working Group , Pandalus division IIIa and IVa east

Year	Denmark LPUE kg/day	Total effort days	Norway LPUE kg/hr	Total effort Khrs	Sweden LPUE kg/hr	Total effort Khrs	average index
1984	452	3869			25	40	
1985	743	6053			32	49	
1986	556	8700	36	179	30	49	1.00
1987	499	9212	36	230	23	57	1.17
1988	432	7104	31	251	22	57	1.13
1989	441	7143	23	273	23	63	1.21
1990	591	4195	26	232	26	58	0.99
1991	645	5555	30	206	31	61	1.01
1992	641	5811	35	204	27	80	1.15
1993	571	5068	31	243	25	91	1.27
1994	677	3146	31	218	33	82	1.08
1995	801	3072	35	255	39	76	1.11
1996	860	4466	37	214	32	74	1.07
1997	1034	3770	42	212	33	78	1.07
1998	1023	3256	44	219	34	73	1.03
1999	833	2501	32	219	34	72	0.99
2000	870	2713	31	195	30	75	0.98
2001	840	2314	32	217	29	74	1.00
2002	1069	2306	39	186	35	65	0.88
2003	1073	3013	47	166	33	72	0.91

Table 4.4 Total international LPUE and effort as estimated by the Working Group ,

Year	LPUE kg/hr	effort Khrs
1984	22.0	345
1985	32.8	388
1986	30.3	424
1987	28.6	494
1988	26.0	468
1989	22.3	497
1990	26.5	384
1991	29.6	392
1992	31.4	415
1993	28.1	448
1994	31.1	371
1995	33.6	400
1996	36.3	388
1997	40.2	375
1998	42.2	365
1999	32.4	347
2000	32.4	331
2001	31.9	343
2002	39.9	303
2003	43.7	306

Table 4.5 Sampling of Pandalus in IVaE and IIIa **2003**

Denmark Quarter	Landing (ton)	N:o samples	Weight (kg)	Numbers measured-sexed
1	1020	2	8.1	2001
2	794	3	12.8	2488
3	688	3	3.3	703
4	743	4	12.4	2174
Total	3245	12	36.5	7366

Norway Quarter	Landing (ton)	N:o samples	Weight (kg)	Numbers measured-sexed
1	2329	2	2.3	407
2	1874	2	2.6	412
3	1977	2	4.6	628
4	1535	surv	83.4	13070
Total	7715		92.9	14517

Sweden Quarter	Landing (ton)	N:o samples	Weight (kg)	Numbers measured-sexed
1	562	2	6	878
2	613	7	23	3700
3	564	6	20	3151
4	650	5	18	2384
Total	2389	20	66.8	10113

Total					Sampling per 1000 ton landed	
Quarter	Landing (ton)	N:o samples	Weight (kg)	Numbers measured-sexed	Weight	Numbers
1	3911		16.1	3286	4.1	840.2
2	3281		38.6	6600	11.8	2011.6
3	3229		28.2	4482	8.7	1388.0
4	2928		113.4	17628	38.7	6020.5
Total	13349		196.2	31996	14.7	2396.9

Table 4.6 Catch in numbers at age. Pandalus division IIIa and IVa east.

Numbers*10**-6

YEAR		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE											
	0	17.7	7.4	2.7	14.1	31.3	0.0	3.9	25.5	27.2	0.7
	1	1200.8	1146.4	1260.5	1086.6	2083.6	2250.1	1231.8	1071.4	1889.6	671.9
	2	1305.4	1029.7	1205.6	923.9	385.5	910.8	1035.8	1289.2	803.8	1380.4
	3	187.9	482.7	390.2	300.2	173.8	121.1	326.7	569.1	262.7	143.0
+gp		52.3	25.1	203.2	146.7	13.6	31.3	25.6	57.5	15.5	30.5
TOTALNUM		**2764.1**	**2691.3**	**3062.1**	**2471.5**	**2687.9**	**3313.3**	**2623.8**	**3012.7**	**2998.7**	**2226.4**
TONSLAND		13273	13233	14876	12929	12193	11421	12107	13556	13475	11761
SOPCOF%		89	97	105	102	106	88	97	88	93	0

YEAR		1995	1996	1997	1998	1999	2000	2001	2002	2003
AGE										
	0	2.7	61.1	19.7	12.7	4.6	88.1	0.0	3.9	2.4
	1	646.0	1211.6	2175.6	903.4	1436.1	1270.7	1308.0	922.3	668.7
	2	970.5	991.4	1181.9	1597.9	720.1	836.3	826.2	858.4	1466.5
	3	851.5	454.6	295.6	468.1	318.3	199.3	382.5	581.8	283.8
+gp		42.0	69.5	29.8	48.2	43.3	39.2	80.8	101.8	0.0
TOTALNUM		**2512.5**	**2788.2**	**3702.6**	**3030.2**	**2522.4**	**2433.5**	**2597.5**	**2468.3**	**2421.4**
TONSLAND		13713	14436	16110	15753	11895	11401	11657	12339	13338
SOPCOF%		87	88	94	96	95	95	90	88	99

Table 4.7 Mean weight at age in catches. Pandalus division IIIa and IVa east.

Catchweights at age (kg)

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
0	0.0009	0.0012	0.0009	0.0009	0.0011	0.0009	0.0015	0.0010	0.0009	0.0009
1	0.0032	0.0032	0.0024	0.0030	0.0034	0.0030	0.0033	0.0035	0.0035	0.0034
2	0.0064	0.0054	0.0048	0.0054	0.0065	0.0053	0.0053	0.0052	0.0067	0.0060
3	0.0104	0.0083	0.0077	0.0090	0.0099	0.0083	0.0079	0.0078	0.0088	0.0093
+gp	0.0134	0.0140	0.0114	0.0117	0.0133	0.0106	0.0122	0.0095	0.0109	0.0117

YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003
AGE									
0	0.0009	0.0007	0.0009	0.0007	0.0007	0.0007	0.0006	0.0008	0.0014
1	0.0033	0.0037	0.0031	0.0033	0.0033	0.0032	0.0031	0.0036	0.0035
2	0.0057	0.0067	0.0061	0.0055	0.0063	0.0063	0.0056	0.0054	0.0060
3	0.0089	0.0094	0.0094	0.0087	0.0088	0.0103	0.0086	0.0083	0.0082
+gp	0.0116	0.0138	0.0119	0.0133	0.0112	0.0139	0.0117	0.0113	0.0121

Table 4.8 **Norwegian shrimp survey in IIIa & IVaE. Catch of *Pandalus.***
Numbers (millions) at age raised to total surveyed area (1-16) .

	Age					
Year	**0**	**1**	**2**	**3**	**4**	**5**
1984	307	2000	844	348	45	1
1985	269	3574	1635	323	144	1
1986	130	1046	685	282	20	0
1987	91	2600	1105	729	93	0
1988	220	337	415	294	53	1
1989	993	1951	447	166	7	0
1990	455	1850	919	98	7	0
1991	224	2521	996	211	26	0
1992	2264	1906	1107	423	38	0
1993	476	3075	890	332	17	0
1994	267	1862	1024	413	136	2
1995	170	1384	759	929	37	0
1996	915	2827	1204	538	42	0
1997	225	3474	1696	715	313	0
1998	331	1096	1375	1027	159	0
1999	309	1938	529	716	45	0
2000	838	2319	900	296	94	5
2001	737	2630	1260	795	124	0
2002	494	3431	1116	653	129	1
2003	179	1144	346	755	424	2
2004	n.a.	5657	1971	1207	390	33

Table 4.9 Shrimp (tonnes) raised to areas , assuming catch efficiency 1.0

Stratum nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total	Input to SPP *)
Area in NM^2	*2794*	*1819*	*342*	*1824*	*1559*	*1392*	*860*	*206*	*431*	*299*	*400*	*295*	*561*	*1685*	*957*	*1136*	*16560*	*13218*
Year																		
1984	0	2441		2144	4048	3093	1313		336	346	316	*556*	605	1253	1305	1535	19291	19291
1985	0	4768		1162	3288	2607	2016	0	815	475	*1900*	794	840	4921	2664	4066	30316	30316
1986	0	2183		920	*933*	1940	663		389	177	*857*	540	618	1521	2073	733	13547	13547
1987	88	3765		2482	4103	3294	1237	0	1370	254	*1470*	584	419	2168	1350	964	23548	23460
1988	0	1126		720	373	1079	682	0	294	96	472	391	282	814	777	343	7449	7449
1989		932		2347	*898*	1722	1159	0	560	263	579	556	498	1375	1443	918	13248	13248
1990	0	705	187	3245	*1067*	2373	471	0	647	171	1044	559	564	2088	1895	907	15920	15733
1991	0	1903	1008	2612	189	2851	1053	152	725	189	740	526	716	2163	2683	1312	18821	17661
1992	0	615	717	585	136	5743	2299	0	568	527	2091	951	669	3567	2550	1211	22229	21512
1993	0	1481	401	4063	*1487*	1437	688		621	281	2596	758	728	2735	3823	1237	22336	21935
1994	0	1391	626	2321	345	2439	1992		461	255	1627	468	844	3004	2284	1320	19377	18751
1995	0	2794		1420	202	4042	953		818	236	1836	513	665	2950	2076	1714	20220	20220
1996	0	4901		1367	133	3576	1108		533	441	3590	616	921	4277	2456	1286	25205	25205
1997	0	7882		1995	416	3393	2406		764	349	1969	1530	1487	3199	3584	3169	32143	32143
1998		5069		3357	586	2223	1049		682	401	1105	451	529	3186	2439	1378	22455	22455
1999	0	5180		5360	3158	3254	1051		235	243	475	266	311	4560	2228	1596	27917	27917
2000		3436		2664	1121	2181	695		343	158	939	380	286	4159	2495	1497	20354	20354
2001		5180	0	5360	3158	3254	1051		307	245	512	266	311	4560	2228	1596	28028	28028
2002		*3922.1*		*3104*	459	3749	1847		1153	364	1403	496	411	5425	4470	3329	30133	30133
2003)**				*1410*	750	2770	840	300	1240	430	480	770	960	2210	1950	850	15070	14660
2004)**		*3590*		*2830*		3540	1530		690	400	120	1390	1230	11060	4650	2890	33920	33920

*) Areas 1,3 and 8 were exluded when biomass indices for the SPP was calculated.
! The value in the greyed cells are estimated from row- and column means !

**) The results from the surveys conducted in 2003 and 2004 are not directly comparable with the previous surveys, see Sect. 4.4.1

Table 4.10 Weight (tonnes) of 0 and1 group shrimp

Year	Age 1(recr indices) (tonnes)	mW (landings) in q4 (grammes)	Age 0 (tonnes)	mW (survey) in q4 (grammes)
1984	7573	3.79	300	0.98
1985	13549	3.79	256	0.95
1986	3327	3.18	134	1.03
1987	6272	2.41	98	1.07
1988	1011	3.00	302	1.37
1989	6586	3.38	1335	1.34
1990	7453	4.03	649	1.43
1991	9289	3.68	337	1.50
1992	8837	4.64	3533	1.56
1993	12358	4.02	603	1.27
1994	8038	4.32	362	1.35
1995	5903	4.27	216	1.27
1996	11993	4.24	1236	1.35
1997	13453	3.87	332	1.48
1998	4667	4.26	447	1.35
1999	8159	4.21	413	1.34
2000	10207	4.40	1211	1.45
2001	10870	4.13	992	1.35
2002	14260	4.16	869	1.76
2003*)	4024	3.52	251	1.40
2004				

*) Based on weights in the catches (WECA)

Table 4.11 **Predators of Pandalus caught in the Norwegian surveys (kg/nautical mile).** (revised WG 03)

Species	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003*)	2004*)	Mean
Blue Whiting ≥30cm	16.1	12.6	12.3	17.4	8.3	18.4	12.4	11.6	15.1	19.6	25	30.5	15.5	19.2	20.7	12.4	10.9	8.9	10.5	4.6	5.4	**14.64**
Saithe	10.9	16.8	12.8	8.9	5.4	3.7	5.6	6.3	6.4	11.8	5.6	13.8	11.4	7.7	21.5	8.7	11.9	10.2	28.4	13.6	20.4	**11.51**
Cod	1.9	3.2	1.8	2.3	1.9	1.9	2.9	1.5	2.3	1.8	2.1	2.7	2.3	3.3	3.7	2.7	2.4	1.2	2.1	1.1	1.9	**2.24**
Roundnosed Grenac	4.2	6	4.9	3.5	3.9	3.5	0.8	3.1	0.8	0.4	1.8	1.6	0.9	1.1	4.3	3.3	2.4	2.4	4.9	3.2	11	**3.24**
Rabbit fish	1.5	2	1.1	1.4	0.8	1.4	2.3	1.4	1.4	1.6	2.4	1.8	2.5	2.8	3.2	3.7	2.9	3.4	2.9	0.7	9.5	**2.41**
Haddock	0.2	0.5	0.4	0.3	0.1	0.3	1.4	0.8	6.4	2.6	2.2	2.1	1.9	3.6	1.4	4.7	3	2.4	3.5	0.8	0.8	**1.88**
Redfishes	1.6	1.8	3.3	1.5	1	1.4	1.2	1.8	3	2.5	1.7	1.7	1.3	1.7	0.9	1	1.3	1.5	0.7	0.1	0.2	**1.49**
Velvet Belly	0.8	1.6	0.7	0.6	2.4	0.5	0.4	0.5	0.7	0.7	0.6	1	1.5	1.2	1.4	9.7	0.8	1.7	0.8	0.7	1.5	**1.42**
Skates,Rays	0.4	1.5	1.5	1.5	0.6	1.6	1.9	1.8	1.3	0.8	1.2	0.7	1.1	1	1.7	0.6	0.6	0.6	0.7	0.2	1.9	**1.10**
Long Rough Dab	0.1	0.6	0.4	0.9	0.6	0.5	0.7	0.6	1.4	0.9	0.9	0.6	0.8	1.8	0.9	0.4	0.5	0.4	0.7	0.6	0.3	**0.70**
Hake	0.5	0.8	1.2	0.5	0.7	1.6	1.2	0.8	1	0.5	0.4	0.3	0.3	0.3	0.5	0.5	0.2	0.3	0.7	0.1	1.5	**0.66**
Angler	0.1	0.5	0.2	0	0.2	0.4	0.4	1	1	0.9	0.6	0.2	0.5	1.4	0.4	0.7	0.6	0.9	0	0.1	2	**0.58**
Witch	0.1	0.6	0.7	0.3	0.2	1	0.4	1.1	0.6	0.2	0.4	0.2	0.3	1	0.7	0.4	0.5	0.4	0.6	0.2	1.1	**0.52**
Dogfish	0.4	1	1.4	0.4	0.7	0.2	1.8	0.3	0.3	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0	0.5	0.2	**0.40**
Whiting	0	0.1	0.3	0.6	0.3	0.8	0.3	0.3	0.5	0.3	0.7	0.6	0	0.6	0.6	0.6	1.1	0.2	0.9	0.6	0	**0.45**
Blue Ling	0.8	0.6	0.2	1.1	0.7	2.8	0.5	0	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	**0.34**
Ling	0.8	0.4	0.1	0.3	0.1	0.1	0.6	0.8	0.8	0.3	0.6	0.4	0.2	0.3	0.4	0.2	0.2	0.3	0.3	0	0.1	**0.35**
Fourbearded Rocklir	0	0.4	0.2	0.2	0.1	0.3	0.2	0.4	0.6	0.3	0.3	0.3	0.4	0.6	0.4	0.2	0.4	0.5	0.2	0.1	0	**0.29**
Tusk	0.3	0.4	0.3	0.2	0.1	0.4	0.4	0.2	0.2	0.2	0.2	0	0.2	0.4	0.4	0.2	0.3	0.7	0	0.1	0.3	**0.26**
Halibut	0	0.3	0	0.2	0.4	0.3	0	0	0.1	0	0	0	0.1	0.2	0	0	0	0	0	0	0	**0.08**
Pollack	0	0	0	0.1	0.1	0.1	0.1	0	0.1	0.1	0.1	0	0.1	0	0	0.7	0	0	0	0	0	**0.07**
Greater Fork-beard	0	0	0	0	0	0.1	0.1	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	**0.01**
SUM Predators	**40.7**	**51.7**	**43.8**	**42.2**	**28.6**	**41.3**	**35.6**	**34.3**	**44.3**	**45.7**	**47.0**	**58.6**	**41.5**	**48.4**	**63.2**	**50.8**	**40.1**	**36.1**	**57.9**	**27.3**	**58.1**	44.63

*) The results from the surveys conducted in 2003 and 2004 are not directly comparable with the previous surveys, see Sect. 4.4.1

Table 4.12 **Input data for the SPP model (2003 assessment)**

Year	Catch tonnes	Recr. Index tonnes	Predator Index kg /NM
1985	13273	7573	40.9
1986	13233	13549	51.7
1987	14876	3327	43.9
1988	12929	6272	42.4
1989	12193	1011	28.6
1990	11421	6586	41.2
1991	12107	7453	35.5
1992	13556	9289	34.4
1993	13475	8837	44.2
1994	11761	12358	45.6
1995	13713	8038	47.0
1996	14436	5903	58.8
1997	16110	11993	41.5
1998	15753	13453	48.3
1999	11895	4667	63.1
2000	11401	8159	50.9
2001	11665	10207	40.1
2002	12339	10870	36.0
Mean 85-02	13119	8308	44

Catches for Div. IIIa+IVaE .
Recruitment index from the Norwegian Trawl Surveys, weight of 1-gr shrimp
Predation index as weight of 23 species per nautical mile.

Table 4.13 **Biomass indices from surveys and output from the model (2003 assessment)**

Year	Total biomass tonnes	Obs. biomass index tonnes*10^{-3}	Calc. biom index tonnes*10^{-3}	Shrimps eaten tonnes
1985	89996	11.4	11.1	27292
1986	91493	16.5	11.3	34487
1987	119848	10.1	14.8	29275
1988	93226	17.1	11.5	28271
1989	86642	6.1	10.7	19070
1990	60110	5.3	7.4	27527
1991	57958	7.6	7.2	23719
1992	63891	8.0	7.9	22974
1993	79503	9.1	9.8	29481
1994	85933	9.0	10.6	30423
1995	113109	10.4	14.0	31359
1996	112478	14.1	13.9	39252
1997	91080	12.0	11.2	27720
1998	114471	18.4	14.1	32240
1999	141738	17.3	17.5	42101
2000	112643	19.3	13.9	33963
2001	112409	8.9	13.9	26767
2002	130774	16.2	16.1	23999
Mean 85-02	97628	12	12	29440

Table 4.14 Proxies for F and M from the SPP model (2003 assessment)

Year	F ≈ Y/B %	M ≈ Shrimp Eaten/B %	"F/M" %
1985	14.6	30.3	48.2
1986	12.5	37.7	33.2
1987	14.0	24.4	57.2
1988	14.4	30.3	47.4
1989	16.6	22.0	75.5
1990	19.3	45.8	42.2
1991	19.9	40.9	48.6
1992	18.9	36.0	52.6
1993	16.3	37.1	43.9
1994	11.8	35.4	33.4
1995	12.2	27.7	43.8
1996	14.2	34.9	40.6
1997	15.7	30.4	51.5
1998	12.3	28.2	43.7
1999	9.4	29.7	31.5
2000	10.1	30.2	33.6
2001	9.6	23.8	40.3
2002	8.6	18.4	47.1
Mean 85-02	13.9	31.3	45.2

Table 4.15 Comparison between 'swept-area' estimates of total biomass and estimates from the SPP model when B_0 equals 90 000 ton

Year	Estimated biomass 'available to trawl' (total survey Area)	Estimated total biomass (total survey Area)	SSP estimates B_0 =90 000 t
1985	19291	96456	89996
1986	30316	151580	91493
1987	13547	67737	119848
1988	23460	117298	93226
1989	7449	37247	86642
1990	13248	66242	60110
1991	15733	78665	57958
1992	17661	88306	63891
1993	21512	107560	79503
1994	21935	109673	85933
1995	18751	93756	113109
1996	20220	101101	112478
1997	25205	126025	91080
1998	32143	160714	114471
1999	22455	112276	141738
2000	27917	139587	112643
2001	20354	101771	112409
2002	28028	140140	130774
2003	30133	150666	154791

Table 5.1 Landings in tonnes of Pandalus borealis from the Fladen Ground (Division IVa) as estimated by the Working Group

Year	Denmark	Norway	Sweden	UK (Scotland)	Total
1972	2204			187	2391
1973	157			163	320
1974	282			434	716
1975	1308			525	1833
1976	1552			1937	3489
1977	425	112		1692	2229
1978	890	81		2027	2998
1979	565	44		268	877
1980	1122	76		377	1575
1981	685	1		347	1033
1982	283			352	635
1983	5729	8		1827	7564
1984	4553	13		25	4591
1985	4188			1341	5529
1986	3416			301	3717
1987	8620			686	9306
1988	1662	2		84	1748
1989	2495	25		547	3067
1990	1681	3	4	365	2053
1991	422	31		53	506
1992	1448			116	1564
1993	1521	38		509	2068
1994	1229	0		35	1264
1995	4659	15		1298	5972
1996	3858	32		1893	5783
1997	3022	9		365	3396
1998	2900	3		1365	4268
1999	1005	9		456	1470
2000	1482			378	1860
2001	1263	18		397	1678
2002	1147	9		70	1226
2003	999	8	1	0	1008

Note: 2003 figures are preliminary.

Table 5.2 Pandalus borealis, Fladen Ground. Reported LPUE (shrimp trawlers), and estimated total effort.

Year	Recorded Denmark LPUE (ton./day)	Total effort (Days)	effort Index	UK (Scotland) LPUE (kg/hour)	Total effort (hours)	effort Index	Combined*) index
1982	0.96	295	0.10	74	4757	0.31	0.21
1983	1.18	4855	1.61	89	20528	1.32	1.54
1984	0.97	4694	1.56	37	676	0.04	1.55
1985	1.21	3016	**1.00**	86	15593	**1.00**	**1.00**
1986	0.96	3558	1.18	71	4239	0.27	1.11
1987	1.24	5908	1.96	81	8469	0.54	1.84
1988	0.83	1298	0.43	44	1909	0.12	0.41
1989	0.99	2463	0.82	65	8415	0.54	0.77
1990	1.28	1313	0.44	106	3493	0.22	0.40
1991	1.50	281	0.09	124	429	0.03	0.09
1992	1.44	1006	0.33	69	1685	0.11	0.32
1993	1.83	831	0.28	90	5656	0.36	0.30
1994	1.93	637	0.21	91	386	0.02	0.21
1995	2.00	2331	0.77	130	9949	0.64	0.74
1996	1.79	2155	0.71	62	30532	1.96	1.12
1997	2.86	1078	0.36	202	1807	0.12	0.33
1998	2.20	1405	0.47	97	14145	0.91	0.61
1999	1.62	606	0.20	107	4263	0.27	0.22
2000	1.79	830	0.28	121	3128	0.20	0.26
2001	2.20	577	0.19	**)	-	-	0.19
2002	1.62	711	0.24	**)	-	-	0.24
2003	1.70	598	0.20	**)	-	-	0.20

*) average weighted by total landings

**) No directed shrimp fishery

Table 6.1 Landings (t) of Pandalus borealis from division IVb, the Farn Deeps as estimated by the Working Group

Year	UK (England)	UK (Scotland)	Denmark	Total
1977	227			
1978	91	2		93
1979	235	34		269
1980	203	17		220
1981	1			1
1982				0
1983	65			65
1984	30			30
1985	2	6		8
1986	137	57	106	300
1987	212	86	92	390
1988	91	25	384	500
1989	168	8	72	248
1990	144		1	145
1991	3		0	3
1992	1		0	1
1993			0	0
1994	4		0	4
1995	171		0	171
1996	58	2	0	60
1997	5		0	5
1998	5		0	5
1999	-	-	0	-
2000	-	-	0	-
2001	-	-	0	-
2002	-	-	0	-
2003	-	-	0	-

Table 7.1 Nominal shrimp catches (t) by country (Sub-areas I and II combined). Data were provided by ICES and Working Group members.

Year	Norway	Russia	Others	Total
1970	5508	0	0	5508
1971	5116	0	0	5116
1972	6772	0	0	6772
1973	6921	0	0	6921
1974	8008	0992	0	9000
1975	8197	0	2	8199
1976	9752	0548	0	10300
1977	6780	12774	4854	24408
1978	20484	15859	0	36343
1979	25435	10864	390	36689
1980	35061	11219	0	46280
1981	32713	10897	1011	44621
1982	43451	15552	3835	62838
1983	70798	29105	4903	104806
1984	76636	43180	8246	128062
1985	82123	32104	10262	124489
1986	48569	10216	6538	65323
1987	31353	6690	5324	43367
1988	32021	12320	4348	48689
1989	47064	12252	3432	62748
1990	54182	20295	6687	81164
1991	39663	29434	6156	75253
1992	39657	20944	8021	68622
1993	32663	22397	806	55866
1994	20116	7108	1063	28287
1995	19337	3564	2319	25220
1996	25445	5747	3320	34512
1997	29079	1493	5164	35736
1998	44792	4895	6103[1]	55790
1999	52612	10765	12292[2]	75669
2000	55333	19596	8241[3]	83170
2001	43021	5875	8136[4]	57032
2002	48799	3802	8105[5]	60706
2003[6]	34652	2775	4372[5]	41800

[1] Catches reported by Estonia, Faroe Island, Iceland, Lithuania, Portugal, Spain and UK(Eng.Wal.NI)
[2] Catches reported by Estonia, Faroe Islands, Germany, Greenland, Iceland, Lithuania, Portugal Spain and UK(Eng.Wal.NI)
[3] Catches reported by Estonia, Faroe Islands, Iceland, Lithuania, Portugal, Spain and UK.
[4] Catches reported by Estonia, Faroe Islands, Lithuania, Portugal, Spain and UK
[5] Catches reported by Estonia, Faroe Islands, Lithuania, Spain and UK
[6] Preliminary data

Table 7.2 Catch (t), effort (h) and CPUE (kg/h) data in ICES sub-areas I, IIa and IIb. Norwegian data based on log books from all vessels and scaled to the level of vessels fishing with single trawl at the size of between 1000hp and 1500hp. Russian data based on daily reports from vessels smaller than 1300hp.

	Norway					Russia		
Year	catch (t)	effort	new effort	new CPUE	CPUE	catch (t)	effort	CPUE
1980	22822	122980	95028	240	186	-	-	-
1981	22458	103725	80641	278	217	2341	8100	289
1982	30961	156224	121602	255	198	4966	20400	243
1983	54521	238724	188601	289	228	13223	48000	276
1984	58489	234786	187559	312	249	33403	118900	281
1985	61704	259503	209538	294	238	27974	110900	252
1986	35650	231269	190033	188	154	7912	33500	236
1987	21354	178807	147747	145	119	3818	23900	160
1988	21587	192451	159265	136	112	9010	61600	146
1989	36673	258188	216314	170	142	7928	53500	148
1990	44626	292714	249792	179	152	17126	94500	181
1991	34409	201912	174577	197	170	15532	74100	210
1992	36861	175262	154213	239	210	13025	57000	229
1993	60508	289795	236255	256	209	11390	60000	190
1994	19108	104789	86636	221	182	4521	27500	164
1995	15662	103585	85292	184	151	3347	26100	128
1996	20343	106343	91242	223	191	5680	35300	161
1997	24525	106406	103776	236	230	1507	7600	198
1998	34080	111651	112825	302	305	4900	21212	231
1999	48369	165821	214860	225	292	6238	30900	202
2000	51939	189028	263483	197	275	12204	71784	170
2001	42158	120787	190991	221	349	2484	16609	150
2002	49480	121605	223785	221	407	3745	21773	172
2003	33173	86163	159611	208	385	2775	16390	127
2004*)	14935	34599	70849	211	432	2077	20134	102

*) Preliminary data

Table 7.3 Indices of shrimp biomass from Norwegian surveys in the years 1982-2002 by main areas.

Main Area	A East Finnmark	B Tiddly Bank	C - Thor Iversen Bank	D - Bear Island Trench	E Hopen	F Bear Island	G Storfjord Trench	H Spits-bergen	Total	Sum. A,B,C, E
Strata	38078	6 - 7	10 - 12	5, 8, 9, 13	14 - 18, 24	19 - 22/ 31 - 40	41 - 50	51 - 70		
1982	35	34	44	53	66	56	17	22	327	179
1983	40	57	61	53	112	52	21	33	429	270
1984	40	51	64	60	141	66	20	29	471	296
1985	23	17	27	18	96	31	17	17	246	163
1986	10	7	13	25	57	34	10	10	166	87
1987	29	13	18	23	31	10	9	13	146	91
1988	26	18	18	36	32	24	13	14	181	94
1989	41	17	13	17	33	53	22	20	216	104
1990	31	13	25	42	58	43	27	23	262	127
1991	22	28	22	54	120	44	21	10	321	192
1992	18	22	33	37	62	38	14	15	239	135
1993	17	19	32	29	85	20	12	19	233	153
1994	19	8	13	15	52	33	9	12	161	92
1995	10	10	11	17	83	33	16	13	193	114
1996	21	8	26	26	110	42	21	22	276	165
1997	24	34	20	34	116	44	12	16	300	194
1998	18	24	41	26	120	72	12	28	341	203
1999	17	19	23	21	169	31	21	16	316	227
2000	14	29	25	26	102	29	10	12	247	170
2001	18	10	30	15	61	25	10	17	184	118
2002	11	18	28	16	86	18	9	10	196	143
2003	15	17	36	12	94	15	8	16	**213**	162
2004	**14**	**24**	**22**	**13**	**46**	**14**	**7**	**11**	**151**	106
% 03/02	34	-3	30	-22	9	-19	-12	60	9	14
% 04/03	-4	38	-39	6	-51	-3	-8	-33	-29	-35

Table 7.4 Indices of shrimp biomass (1000 t) from Russian survey in the 1984-2002 by main areas. Catchability of 0.182 is used in the estimate.

Main Area	A East Finmark	B Tiddly Bank	C-Thor Iversen Bank	E Hopen	F Bear Island	G Storfiord Trench	H Spits-bergen	I Kola coast	K Goose Bank	Total	Sum. A,B,C,E
Strata	1-4	6,7,1s	10-12,25	14-18	38-40, 43-45	48-50	53-55,58-60, 63-65,58-70	2s-6s	7s-8s		
1984	38	137	99	254				133		661	528
1985	14	45	74	255		6	46	19	9	468	388
1986	9	19	44	140		42	127	9	9	399	212
1987	16	17	59	107	45	36	27	25	14	346	199
1988	14	31	39	49		22	29	36	13	233	133
1989	70	128	57	132	6	60	25	105	20	603	387
1990	90	195	119	259	14	110	30	196	15	1028	663
1991	90	153	104	541	9	70	27	155	43	1192	888
1992	80	153	92	409				65	77	876	734
1993	45	91	159	382	9		58	37	111	892	677
1994	4	35	48	255	21			14	27	404	342
1995	5	28	15	80	33	53		16	18	248	128
1996	20	98	127		21			67	108	441	245
1997	26	108	130	341				108	52	765	605
1998	14	106	136	172				108	41	576	427
1999	43	139	107	523				93	61	966	812
2000	29	73	109	328	9	39		72	141	800	539
2001	11	52	105	185	19	14	13	14	55	468	353
2002	30	129	198	353	15	39	51	70	105	980	710
% 01/00	-62	-29	-4	-44	111	-64		-81	-61	-42	-35
% 02/01	173	148	89	91	-21	179	292	400	91	109	101

Table 7.5 Shrimp in the Barents Sea defined as index of numbers in size groups according to carapace length at age and number of egg bearing females contributing to the recruitment (SSN) in the Norwegian Barents sea survey (whole mm).

CL (mm)	<9	9<cl<13	13<cl<17	17<cl<19	>19mm	
year	1	2	3	4	5+	SSN
1990		8	192	357	567	131
1991		59	213	391	756	123
1992		84	308	291	567	109
1993		44	355	316	405	101
1994		23	186	221	250	30
1995	0,4	20	238	233	307	9
1996	0,2	27	335	374	367	25
1997	0,5	22	372	511	440	47
1998	0,8	9	374	517	567	51
1999	1,3	12	192	357	510	111
2000	2,6	33	147	278	559	66
2001	2,1	20	138	138	410	61
2002	1,1	22	218	295	390	165
2003	0,5	19	254	249	362	110
2004	0,7	5	106	198	295	75

Table 7.6 Biomass indices for shrimp from the Norwegian surveys, biomass estimate for cod (age 3 years and older) and the shrimp consumed by the cod in the Barents Sea.

Year	Cod (3+)	Shrimp index	Shrimp consumed
1984	818	471	436
1985	957	246	155
1986	1292	166	142
1987	1120	146	191
1988	913	181	129
1989	891	216	132
1990	963	262	194
1991	1560	321	188
1992	1910	239	373
1993	2355	233	315
1994	2149	161	516
1995	1815	193	362
1996	1700	276	341
1997	1526	300	311
1998	1221	341	325
1999	1097	316	256
2000	1108	247	459
2001	1393	184	288
2002	1593	196	247
2003	1815	212	285
2004	1749	151	

Tables 8.1 A - G 1994 - 2003

A:

Skagerrak, Sub-div. IIIA. **Danish log book records**

Species:	1994 Tons	1994 % of total catch	1995 Tons	1995 % of total catch	1996 Tons	1996 % of total catch	1997 Total	1997 % of total catch	1998 Total	1998 % of total catch	1999 Total	1999 % of total catch	2000 Total	2000 % of total catch	2001 Total	2001 % of total catch	2002 Total	2002 % of total catch	2003 Total	2003 % of total catch
Blue Whiting	289.2	9.5	151.6	4.8	88.5	2.0	97.5	2.3	53.4	1.5	8.1	0.5	1.4	0.1	0.1	0.0	128.4	5.2	0.0	0.0
Norway lobster	17.3	0.6	28.3	0.9	65.5	1.5	38.8	0.9	31.0	0.9	22.1	1.3	18.6	0.8	14.4	1.0	13.9	0.6	31.2	1.0
Pandalus	2001.0	66.0	2421.0	76.1	3664.2	82.1	3617.0	84.4	2933.0	83.0	1398.5	81.8	1897.6	83.9	1185.9	84.3	1966.6	79.2	2562.2	83.0
Angler fish	16.2	0.5	12.3	0.4	28.5	0.6	18.7	0.4	12.5	0.4	8.0	0.5	12.4	0.5	10.0	0.7	13.2	0.5	6.6	0.2
Whiting	1.1	0.0	0.1	0.0	0.9	0.0	0.9	0.0	0.2	0.0	0.4	0.0	0.4	0.0	0.0	0.0	0.3	0.0	1.0	0.0
Haddock	16.4	0.5	10.8	0.3	19.8	0.4	9.3	0.2	17.8	0.5	9.7	0.6	11.3	0.5	13.1	0.9	72.1	2.9	79.5	2.6
Hake	8.3	0.3	3.9	0.1	7.3	0.2	6.2	0.1	2.9	0.1	2.8	0.2	3.8	0.2	7.5	0.5	4.7	0.2	5.0	0.2
Ling	1.3	0.0	0.7	0.0	1.1	0.0	0.4	0.0	0.7	0.0	0.6	0.0	0.5	0.0	0.4	0.0	0.5	0.0	1.0	0.0
Saithe	7.7	0.3	6.0	0.2	82.6	1.9	80.8	1.9	85.6	2.4	41.0	2.4	53.9	2.4	52.6	3.7	129.1	5.2	210.2	6.8
Witch flounder	19.5	0.6	39.8	1.3	32.5	0.7	33.8	0.8	66.6	1.9	56.1	3.3	104.5	4.6	32.6	2.3	37.6	1.5	42.8	1.4
Norway pout	383.1	12.6	144.3	4.5	114.6	2.6	83.9	2.0	29.9	0.8	0.5	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Cod	100.2	3.3	159.0	5.0	179.5	4.0	187.8	4.4	188.4	5.3	100.9	5.9	84.7	3.7	51.6	3.7	72.6	2.9	87.4	2.8
Other market fish	6.0	0.2	6.2	0.2	5.7	0.1	5.1	0.1	6.1	0.2	3.7	0.2	6.2	0.3	2.9	0.2	4.5	0.2	7.1	0.2
Fish for reduction	164.0	5.4	196.9	6.2	173.4	3.9	106.6	2.5	105.6	3.0	57.7	3.4	65.5	2.9	35.0	2.5	40.6	1.6	53.9	1.7
Cod as % of shrimp:		5.0		6.6		4.9		5.2		6.4		7.2		4.5		4.4		3.7		3.4
Total H.C. as % of shrimp:		9.7		11.0		11.6		10.6		14.0		17.5		15.6		15.6		17.7		18.4

B: 17.7194

Skagerrak, Sub-div. IIIA. **Swedish log book records**

Species:	1994 Tons	1994 % of total catch	1995 Tons	1995 % of total catch	1996 Tons	1996 % of total catch	1997 Total	1997 % of total catch	1998 Total	1998 % of total catch	1999 Total	1999 % of total catch	2000 Total	2000 % of total catch	2001 Total	2001 % of total catch	2002 Total	2002 % of total catch	2003 Total	2003 % of total catch
Blue Whiting		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	16.0	0.8
Norway lobster	18.0	0.7	23.0	0.9	24.0	1.1	19.0	0.8	30.0	1.3	27.0	1.2	23.0	1.1	13.0	0.6	10.0	0.5	10.1	0.5
Pandalus	2285.0	89.4	2453.0	93.6	1978.0	89.2	2092.0	89.2	2044.0	86.1	2107.0	89.9	1885.0	88.6	1815.0	89.3	1836.0	85.0	1769.8	85.9
Angler fish	3.0	0.1	3.0	0.1	2.0	0.1	4.0	0.2	3.0	0.1	3.0	0.1	3.0	0.1	5.0	0.2	4.0	0.2	2.6	0.1
Whiting	2.0	0.1	1.0	0.0	2.0	0.1	3.0	0.1	1.0	0.0	2.0	0.1	3.0	0.1	3.0	0.1	6.0	0.3	3.5	0.2
Haddock	17.0	0.7	17.0	0.6	11.0	0.5	15.0	0.6	40.0	1.7	11.0	0.5	18.0	0.8	29.0	1.4	55.0	2.5	18.4	0.9
Hake	4.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.0	0.1	2.0	0.1	2.0	0.1	1.6	0.1
Ling	4.0	0.2	2.0	0.1	3.0	0.1	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	2.0	0.1	1.2	0.1
Saithe	6.0	0.2	3.0	0.1	57.0	2.6	84.0	3.6	91.0	3.8	31.0	1.3	31.0	1.5	26.0	1.3	119.0	5.5	144.5	7.0
Witch flounder	17.0	0.7	16.0	0.6	11.0	0.5	23.0	1.0	38.0	1.6	58.0	2.5	71.0	3.3	46.0	2.3	51.0	2.4	39.8	1.9
Norway pout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cod	54.0	2.1	69.0	2.6	95.0	4.3	70.0	3.0	89.0	3.8	74.0	3.2	65.0	3.1	51.0	2.5	59.0	2.7	34.5	1.7
Other market fish	9.0	0.4	5.0	0.2	8.0	0.4	9.0	0.4	7.0	0.3	5.0	0.2	6.0	0.3	4.0	0.2	1.0	0.0	17.3	0.8
Fish for reduction	137.0	5.4	28.0	1.1	26.0	1.2	26.0	1.1	29.0	1.2	23.0	1.0	19.0	0.9	37.0	1.8	14.0	0.6	0.1	0.0
Cod as % of shrimp:		2.4		2.8		4.8		3.3		4.4		3.5		3.4		2.8		3.2	2059.4	1.9
Total H.C. as % of shrimp:		5.9		5.7		10.8		10.9		14.7		10.1		11.8		9.9		16.8		15.5

C:
Skagerrak, Sub-div. IIIA. **Swedisl Swedish log bo Trawls with selective grids**

Species:	1994 Tons	1994 % of total catch	1995 Tons	1995 % of total catch	1996 Tons	1996 % of total catch	1997 Total	1997 % of total catch	1998 Total	1998 % of total catch	1999 Total	1999 % of total catch	2000 Total	2000 % of total catch	2001 Total	2001 % of total catch	2002 Total	2002 % of total catch	2003 Total	2003 % of total catch
Blue Whiting								0.0		0.0		0.0				0.0		0.0	0.0	0.0
Norway lobster							0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	1.0	0.6	0.4	0.2
Pandalus							1.0	100.0	35.0	100.0	1.0	100.0	0.0		21.0	100.0	177.0	99.4	232.7	98.5
Angler fish							0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Whiting								0.0		0.0		0.0				0.0		0.0	0.1	0.0
Haddock								0.0		0.0		0.0				0.0		0.0	0.4	0.2
Hake								0.0		0.0		0.0				0.0		0.0	0.0	0.0
Ling								0.0		0.0		0.0				0.0		0.0	0.0	0.0
Saithe							0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	2.0	0.8
Witch flounder								0.0		0.0		0.0				0.0		0.0	0.2	0.1
Norway pout								0.0		0.0		0.0				0.0		0.0	0.0	0.0
Cod								0.0		0.0		0.0				0.0		0.0	0.2	0.1
Other market fish								0.0		0.0		0.0				0.0		0.0	0.2	0.1
Fish for reduction								0.0		0.0		0.0				0.0		0.0	0.0	0.0
Cod as % of shrimp:										0.0								0.0	236.2	0.1
Total H.C. as % of shrimp:								0.0		0.0		0.0				0.0		0.6		1.5

D:
Skagerrak, Sub-div. IIIA. **Norwegian logbook records (* new log book format)**

Species:	1994 Tons	1994 % of total catch	1995 Tons	1995 % of total catch	1996 Tons	1996 % of total catch	1997 Total	1997 % of total catch	1998 Total	1998 % of total catch	1999 Total	1999 % of total catch	2000 Total	2000 % of total catch	2001 Total	2001 % of total catch	2002* Total	2002* % of total catch	2003* Total	2003* % of total catch
Blue Whiting									12.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Norway lobster									3.0	0.2	7.0	0.5	9.0	0.8	20.0	1.2	37.0	0.9	28.0	0.7
Pandalus									1689.0	87.5	1328.0	87.9	1031.0	86.2	1461.0	88.3	3663.0	87.3	3700.0	86.3
Angler fish									9.0	0.5	11.0	0.7	13.0	1.1	13.0	0.8	32.0	0.8	26.0	0.6
Whiting									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.3	14.0	0.3
Haddock									1.0	0.1	4.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hake									1.0	0.1	1.0	0.1	2.0	0.2	2.0	0.1	6.0	0.1	6.0	0.1
Ling									4.0	0.2	5.0	0.3	6.0	0.5	4.0	0.2	26.0	0.6	28.0	0.7
Saithe									15.0	0.8	27.0	1.8	26.0	2.2	34.0	2.1	43.0	1.0	58.0	1.4
Witch flounder									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.0	0.9	34.0	0.8
Norway pout									41.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cod									30.0	1.6	25.0	1.7	24.0	2.0	20.0	1.2	153.0	3.6	184.0	4.3
Other market fish									126.0	6.5	103.0	6.8	85.0	7.1	101.0	6.1	187.0	4.5	208.0	4.9
Fish for reduction									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cod as % of shrimp:										1.8		1.9		2.3		1.4		4.2		5.0
Total H.C. as % of shrimp:										13.6		13.8		16.0		13.3		14.6		15.8

E:

Norwegian Deeps, Sub-div. IVA East **Danish log book records**

Species:	1994 Tons	1994 % of total catch	1995 Tons	1995 % of total catch	1996 Tons	1996 % of total catch	1997 Total	1997 % of total catch	1998 Total	1998 % of total catch	1999 Total	1999 % of total catch	2000 Total	2000 % of total catch	2001 Total	2001 % of total catch	2002 Total	2002 % of total catch	2003 Total	2003 % of total catch
Blue Whiting	11.7	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.1	2.4	0.2	7.2	1.1	2.7	0.3	0.6	0.1	0.4	0.0
Norway lobster	2.8	1.4	3.7	6.9	22.4	8.1	15.6	4.2	50.8	9.0	57.0	5.7	23.8	3.8	20.3	2.1	20.8	3.2	9.9	1.2
Pandalus	132.9	67.2	39.5	74.1	203.7	73.4	291.8	78.6	397.2	70.2	673.5	67.4	473.7	75.5	767.2	77.6	500.2	76.3	661.1	81.5
Angler fish	10.4	5.2	1.7	3.3	14.8	5.3	10.4	2.8	27.4	4.8	56.8	5.7	22.6	3.6	27.2	2.8	16.9	2.6	15.3	1.9
Whiting	0.2	0.1	0.0	0.0	0.1	0.0	0.6	0.2	1.0	0.2	0.9	0.1	0.2	0.0	0.8	0.1	0.4	0.1	1.8	0.2
Haddock	2.2	1.1	0.1	0.2	1.9	0.7	1.1	0.3	1.9	0.3	13.8	1.4	2.5	0.4	5.6	0.6	4.5	0.7	7.4	0.9
Hake	2.6	1.3	0.6	1.2	2.4	0.8	3.2	0.9	2.3	0.4	3.0	0.3	8.9	1.4	7.3	0.7	6.9	1.1	2.8	0.3
Ling	3.0	1.5	0.5	1.0	1.1	0.4	2.4	0.6	5.8	1.0	19.4	1.9	6.2	1.0	11.6	1.2	5.9	0.9	4.6	0.6
Saithe	3.3	1.7	0.9	1.7	8.1	2.9	18.1	4.9	28.5	5.0	81.1	8.1	36.8	5.9	81.7	8.3	52.8	8.1	62.4	7.7
Witch flounder	2.7	1.4	0.7	1.2	1.5	0.5	2.0	0.5	7.0	1.2	6.8	0.7	2.4	0.4	7.0	0.7	2.0	0.3	2.9	0.4
Norway pout	13.3	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1	4.5	0.5	1.0	0.1	1.8	0.2
Cod	6.8	3.4	2.5	4.7	13.9	5.0	17.8	4.8	28.2	5.0	56.2	5.6	29.2	4.7	34.5	3.5	30.1	4.6	30.5	3.8
Other market fish	1.2	0.6	0.7	1.4	2.2	0.8	1.1	0.3	3.6	0.6	7.2	0.7	0.8	0.1	3.9	0.4	1.9	0.3	0.6	0.1
Fish for reduction	4.8	2.4	2.3	4.4	5.7	2.1	6.9	1.9	11.5	2.0	21.6	2.2	12.8	2.0	14.8	1.5	11.5	1.7	9.3	1.2
Cod as % of shrimp:		5.1		6.4		6.8		6.1		7.1		8.3		6.2		4.5		6.0		4.6
Total H.C. as % of shrimp:		36.5		29.1		33.5		24.8		39.4		44.9		28.2		26.6		28.6		21.2

F:

Norwegian Deeps, Sub-div. IVA East **Norwegian logbook records**

Species:	1994 Tons	1994 % of total catch	1995 Tons	1995 % of total catch	1996 Tons	1996 % of total catch	1997 Total	1997 % of total catch	1998 Total	1998 % of total catch	1999 Total	1999 % of total catch	2000 Total	2000 % of total catch	2001 Total	2001 % of total catch	2002* Total	2002* % of total catch	2003* Total	2003* % of total catch
Blue Whiting									12.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Norway lobster									3.0	0.2	7.0	0.5	9.0	0.8	20.0	1.2	14.0	0.5	15.0	0.3
Pandalus									1689.0	87.5	1328.0	87.9	1031.0	86.2	1461.0	88.3	3599.0	89.6	3927.0	85.6
Angler fish									9.0	0.5	11.0	0.7	13.0	1.1	13.0	0.8	158.0	0.9	135.0	2.9
Whiting									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	11.0	0.2
Haddock									1.0	0.1	4.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hake									1.0	0.1	1.0	0.1	2.0	0.2	2.0	0.1	12.0	0.3	13.0	0.3
Ling									4.0	0.2	5.0	0.3	6.0	0.5	4.0	0.2	44.0	0.3	34.0	0.7
Saithe									15.0	0.8	27.0	1.8	26.0	2.2	34.0	2.1	137.0	1.3	164.0	3.6
Witch flounder									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	5.0	0.1
Norway pout									41.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cod									30.0	1.6	25.0	1.7	24.0	2.0	20.0	1.2	127.0	0.9	125.0	2.7
Other market fish									126.0	6.5	103.0	6.8	85.0	7.1	101.0	6.1	127.0	6.4	158.0	3.4
Fish for reduction									0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cod as % of shrimp:										1.8		1.9		2.3		1.4		3.5		3.2
Total H.C. as % of shrimp:										13.6		13.8		16.0		13.3		17.7		16.8

G:
Fladen Ground, Sub_div. IVA. **Danish log book records**

Species:	1994 Tons	1994 % of total catch	1995 Tons	1995 % of total catch	1996 Tons	1996 % of total catch	1997 Total	1997 % of total catch	1998 Total	1998 % of total catch	1999 Total	1999 % of total catch	2000 Total	2000 % of total catch	2001 Total	2001 % of total catch	2002 Total	2002 % of total catch	2003 Total	2003 % of total catch
Blue Whiting	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Norway lobster	31.7	2.2	119.2	2.2	104.2	2.2	44.0	1.3	134.6	3.9	40.2	3.2	42.5	2.5	17.6	1.3	37.8	2.7	21.7	1.9
Pandalus	1229.1	86.1	4658.5	85.5	3858.4	82.6	3022.2	89.0	2899.8	84.1	1004.6	80.5	1482.4	86.6	1263.3	92.5	1147.1	81.9	1001.3	85.6
Angler fish	37.5	2.6	145.3	2.7	192.5	4.1	60.1	1.8	57.9	1.7	28.2	2.3	30.5	1.8	19.0	1.4	28.1	2.0	19.9	1.7
Whiting	9.4	0.7	9.3	0.2	6.0	0.1	0.6	0.0	2.1	0.1	0.5	0.0	2.5	0.1	0.2	0.0	2.7	0.2	0.6	0.0
Haddock	17.5	1.2	54.0	1.0	59.3	1.3	16.2	0.5	34.8	1.0	49.7	4.0	33.4	2.0	4.1	0.3	20.0	1.4	28.5	2.4
Hake	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Ling	1.9	0.1	6.2	0.1	3.2	0.1	1.1	0.0	1.0	0.0	0.4	0.0	0.8	0.0	0.1	0.0	0.5	0.0	0.2	0.0
Saithe	6.4	0.4	31.9	0.6	31.9	0.7	9.7	0.3	50.2	1.5	27.4	2.2	21.0	1.2	19.3	1.4	62.2	4.4	43.0	3.7
Witch flounder	0.2	0.0	1.2	0.0	4.1	0.1	0.4	0.0	1.0	0.0	0.2	0.0	0.8	0.0	0.0	0.0	0.1	0.0	1.7	0.1
Norway pout	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cod	80.9	5.7	378.5	6.9	371.9	8.0	223.5	6.6	235.3	6.8	85.6	6.9	84.8	5.0	34.3	2.5	93.9	6.7	47.5	4.1
Other market fish	0.6	0.0	3.3	0.1	6.2	0.1	0.2	0.0	0.5	0.0	0.1	0.0	0.5	0.0	0.0	0.0	1.0	0.1	0.2	0.0
Fish for reduction	11.8	0.8	39.8	0.7	34.9	0.7	17.6	0.5	30.7	0.9	10.8	0.9	11.7	0.7	7.2	0.5	7.1	0.5	5.5	0.5
Cod as % of shrimp:		6.6		8.1		9.6		7.4		8.1		8.5		5.7		2.7		8.2		4.7
Total H.C. as % of shrimp:		15.1		16.1		20.2		11.8		17.8		23.1		14.6		7.5		21.5		16.3

Table 9.1 Northeast Arctic cod weight (tonnes) and numbers taken as bycatch in the shrimp fishery (1983-2002).

Cod by-catch	2001		2002	
Fish length (cm)	weight	numbers	weight	numbers
4	0			
5	0			
6	0,06	39795		
7	0,12	47175	3	42927
8	1,49	379074	5	190416
9	2,21	393002	10	713464
10	4,75	612643	15	890682
11	15,46	1490688	16	542936
12	28,96	2141669	22	589909
13	44,66	2586164	27	574110
14	44,09	2036305	34	572853
15	45,57	1705141	46	733283
16	44,8	1376351	56	734496
17	34,69	885744	79	1034145
18	26,85	575795	105	1270462
19	26,48	481498	118	1174854
20	22,18	344742	116	828780
21	10,59	141811	108	467373
22	5,52	64136	103	220620
23	4,59	46565	110	138318
24	0,82	7320	123	119107
25	1,86	14620	129	34477
Total	366	15370239	1224	10873211
Shrimp c.c.	46704	46704	42108	42108
Cod as % of shrimp	0,008		0,007	

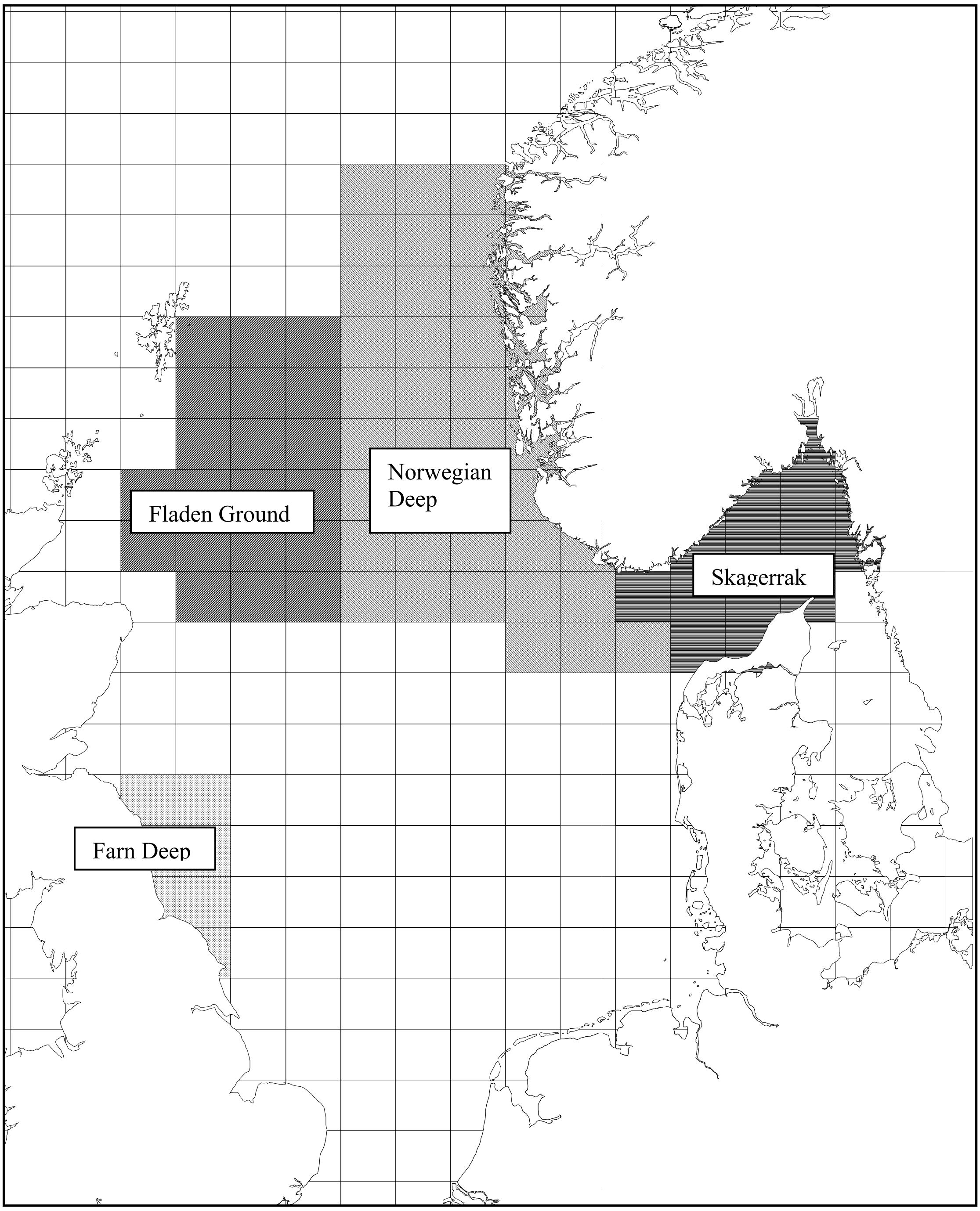


Figure 3.1. The distribution of the *Pandalus* stocks in the North Sea area as defined by the ICES squares.

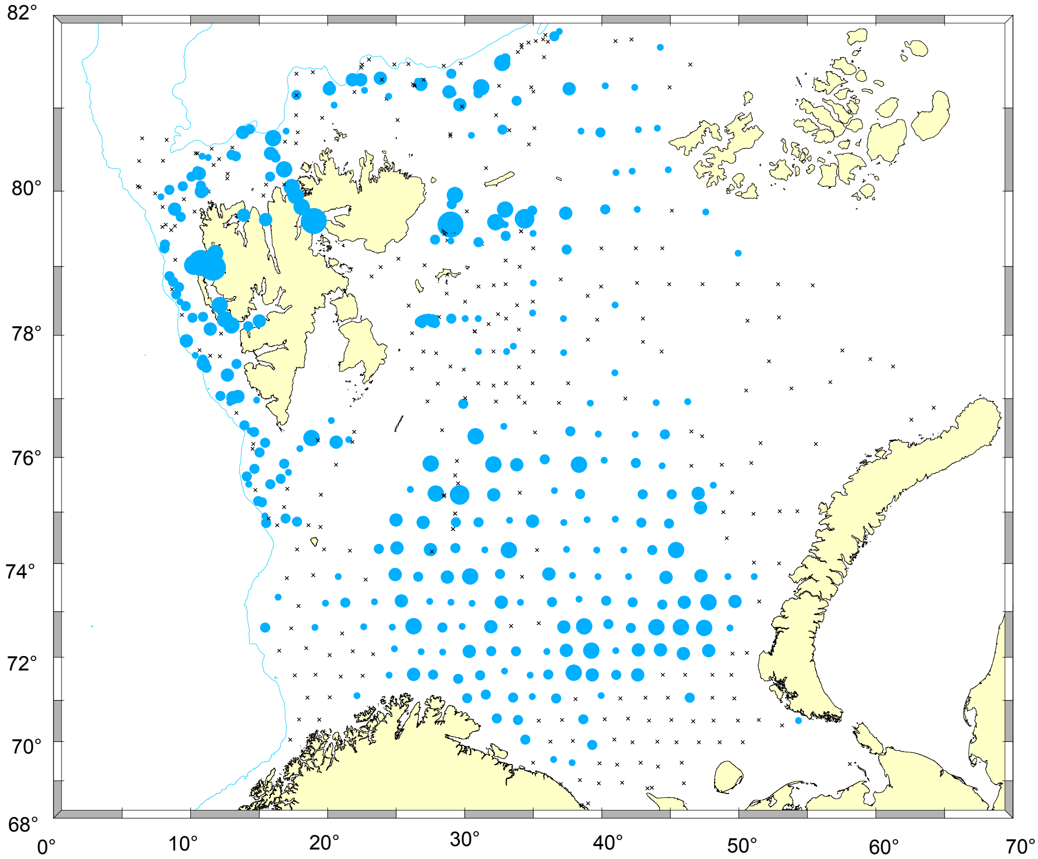


Figure 3.2 Shrimp distribution in the Barents Sea according to Surveys conducted in the period August-October 2004.

Figure 4.1

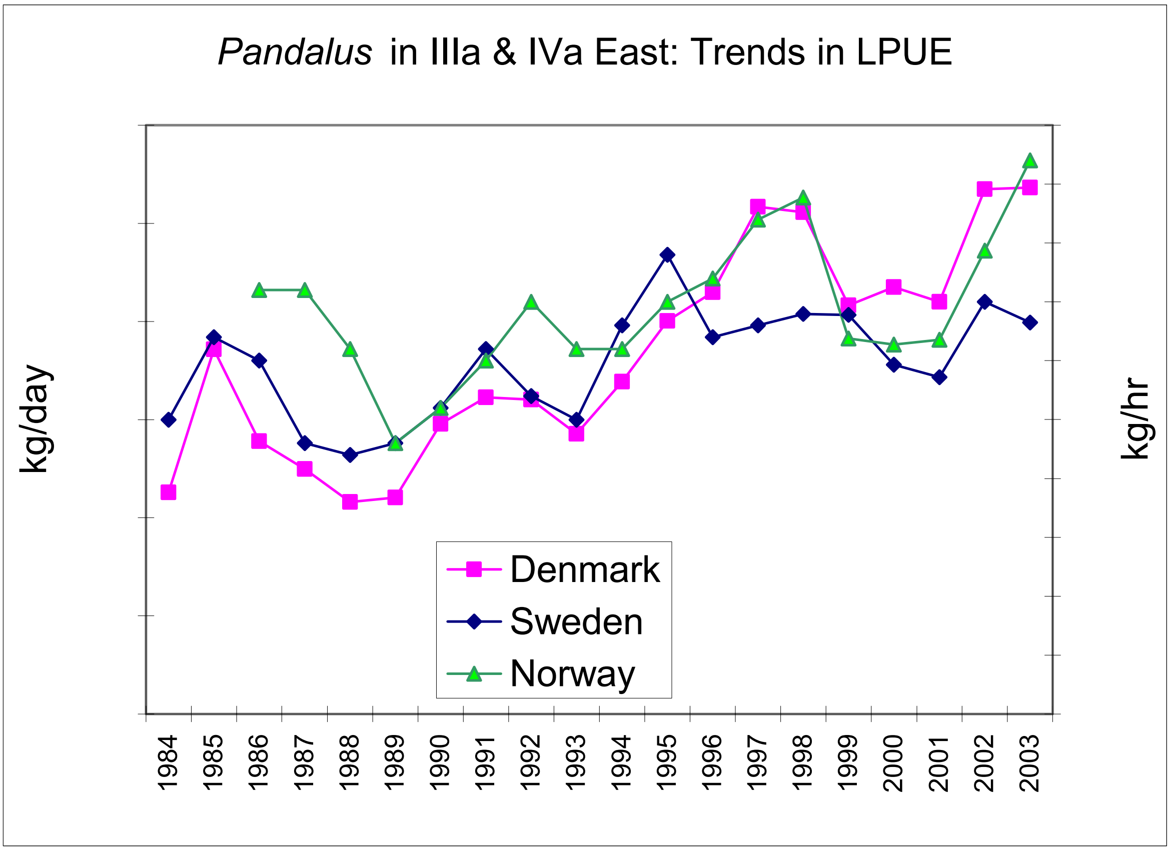


Figure 4.2

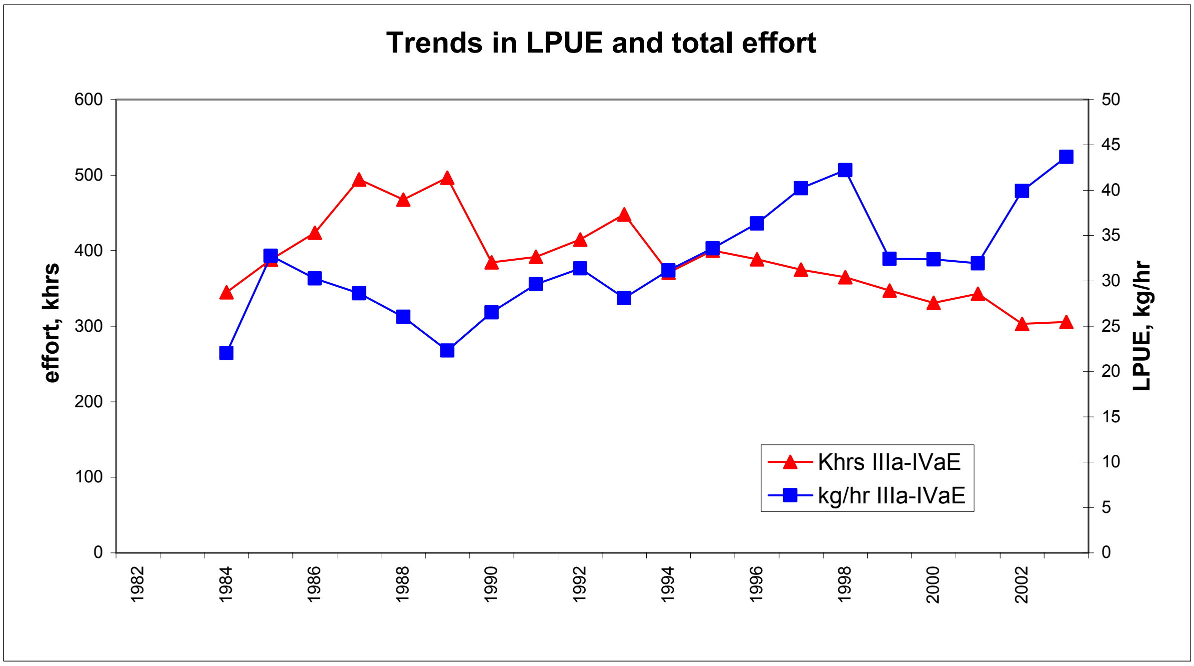


Figure 4.3 Mean quarterly carapace length (mm) for Pandalus in Div. IIIa and IVaEast

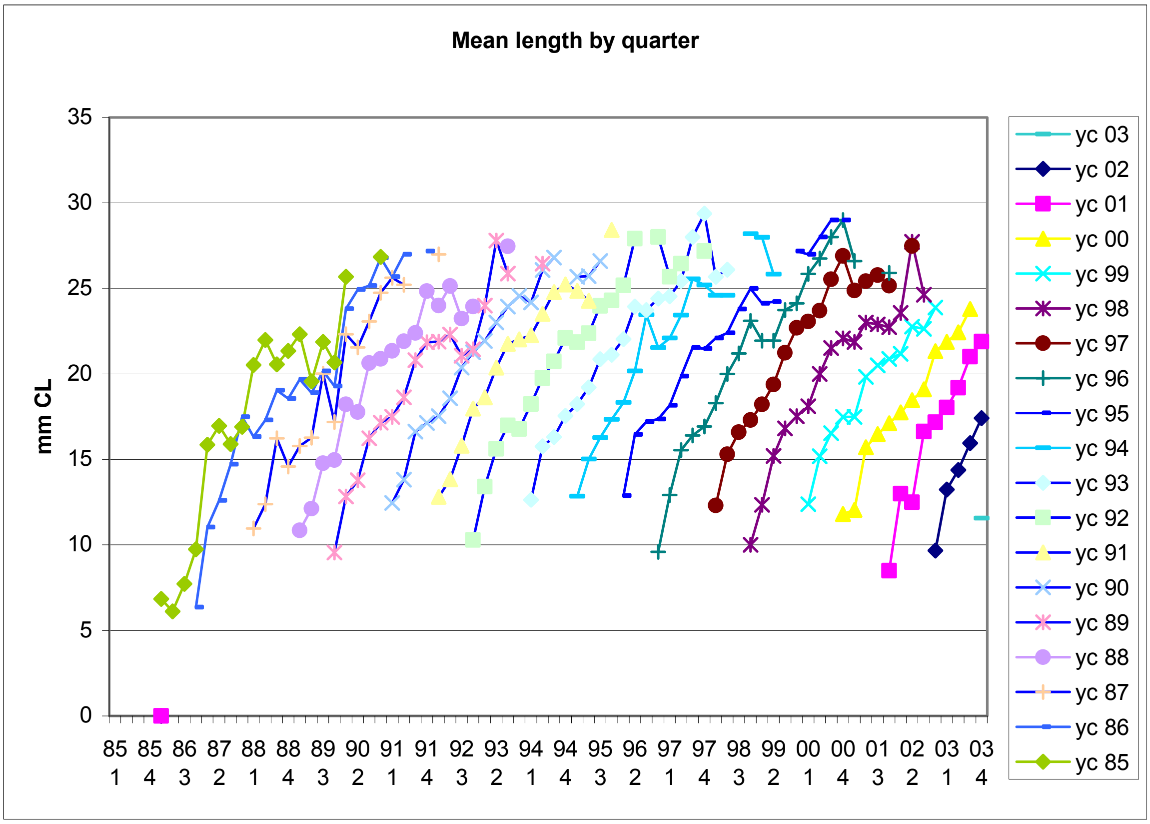


Figure 4.4 Norwegian Trawl Survey Area. Strata 1-16 and depth contour lines.

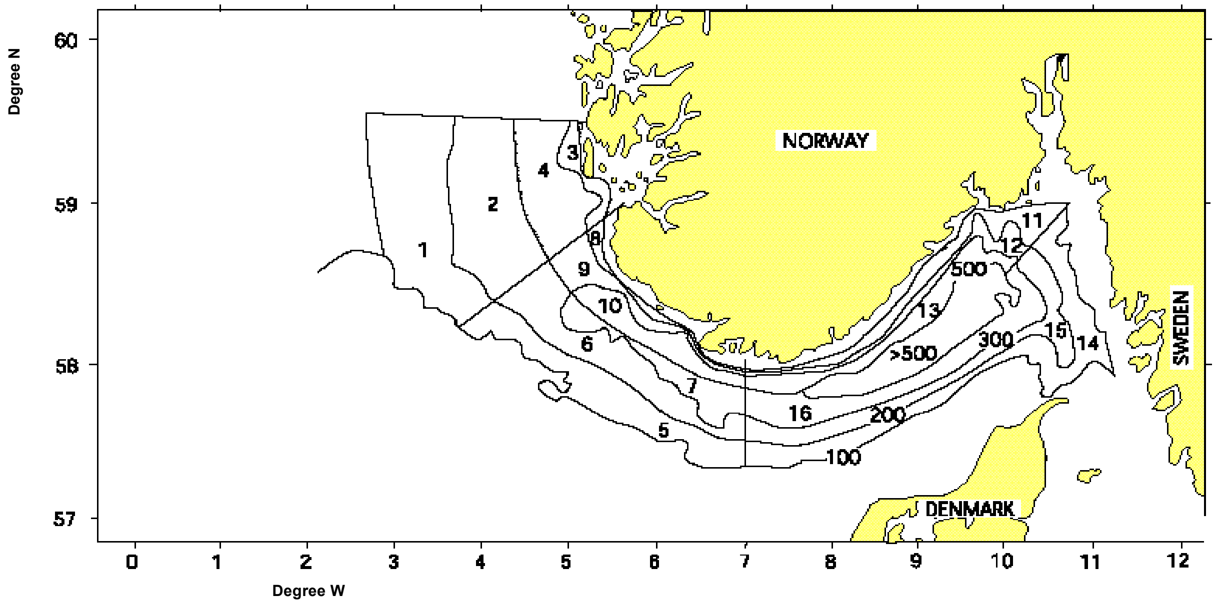


Figure 4.5 Relation between fitted and observed Biomass indices

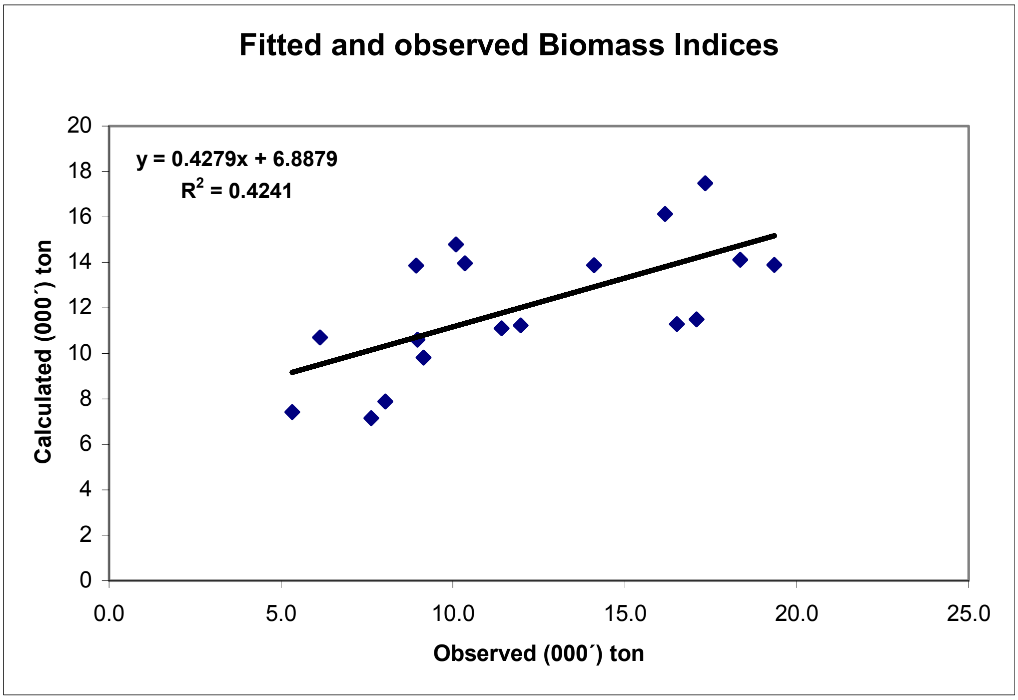


Figure 4.6 SPP estimated biomass and international LPUE

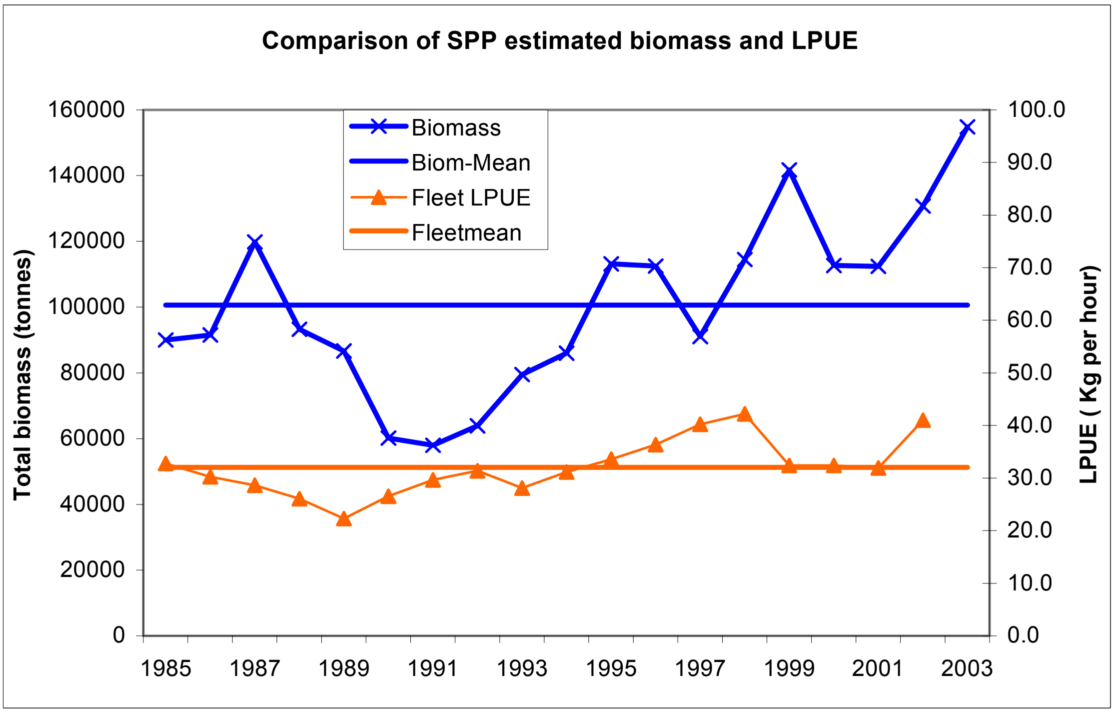
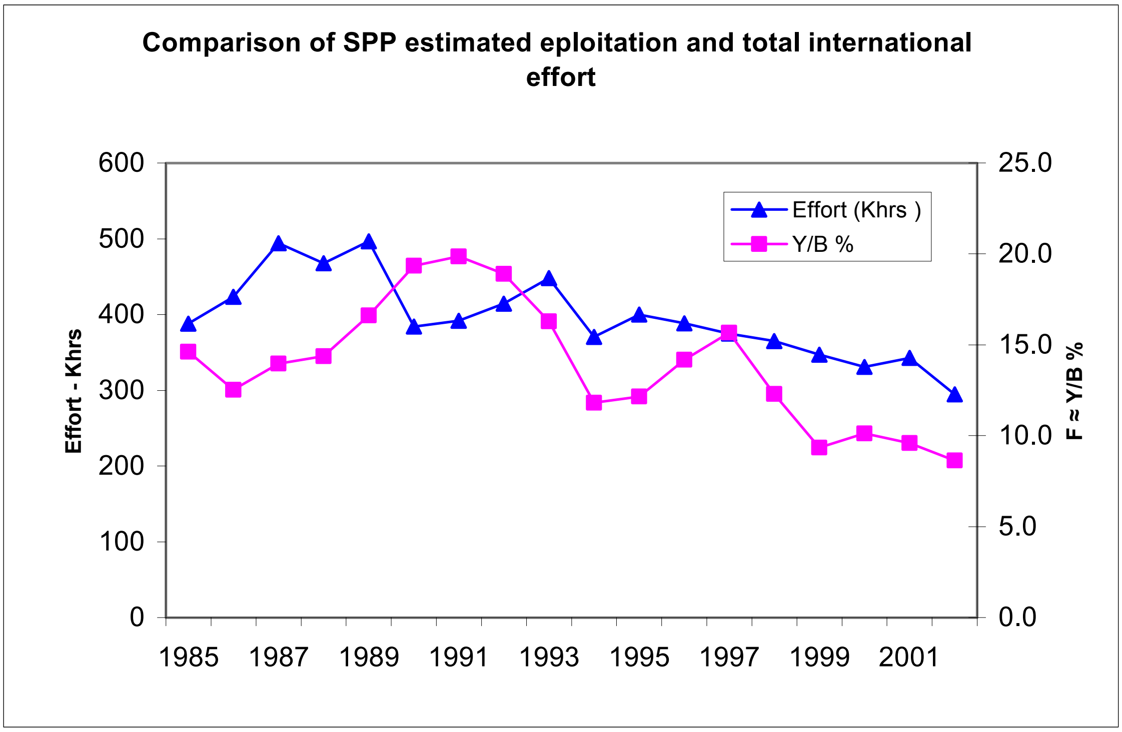


Figure 4.7 Estimated international effort and eploitation level from SPP



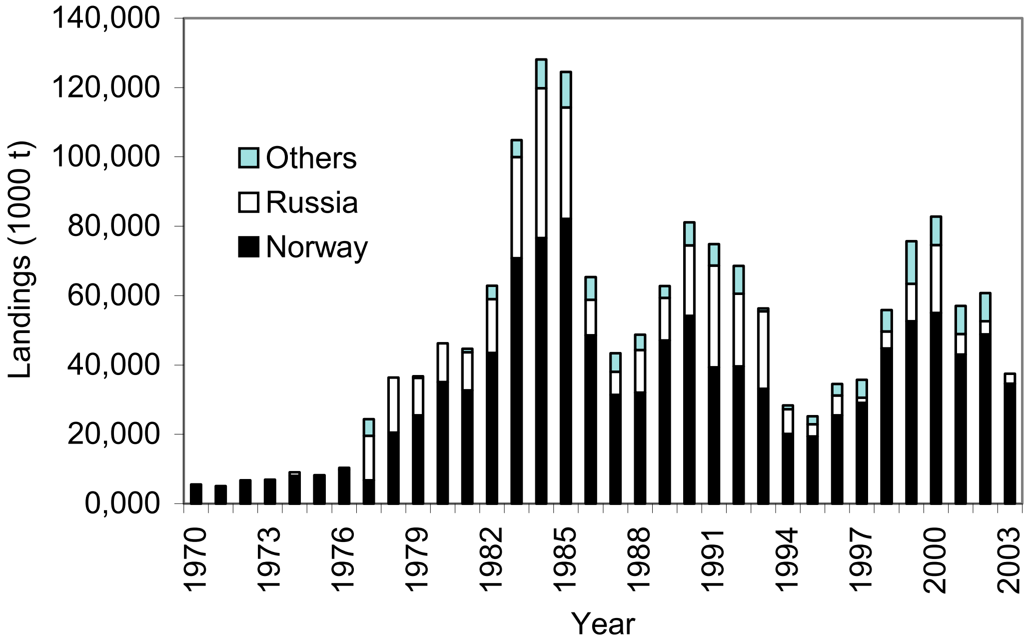


Figure 7.1 Shrimp landings from ICES areas I, IIa and IIb by Norway, Russia and other countries in the period 1970–2003

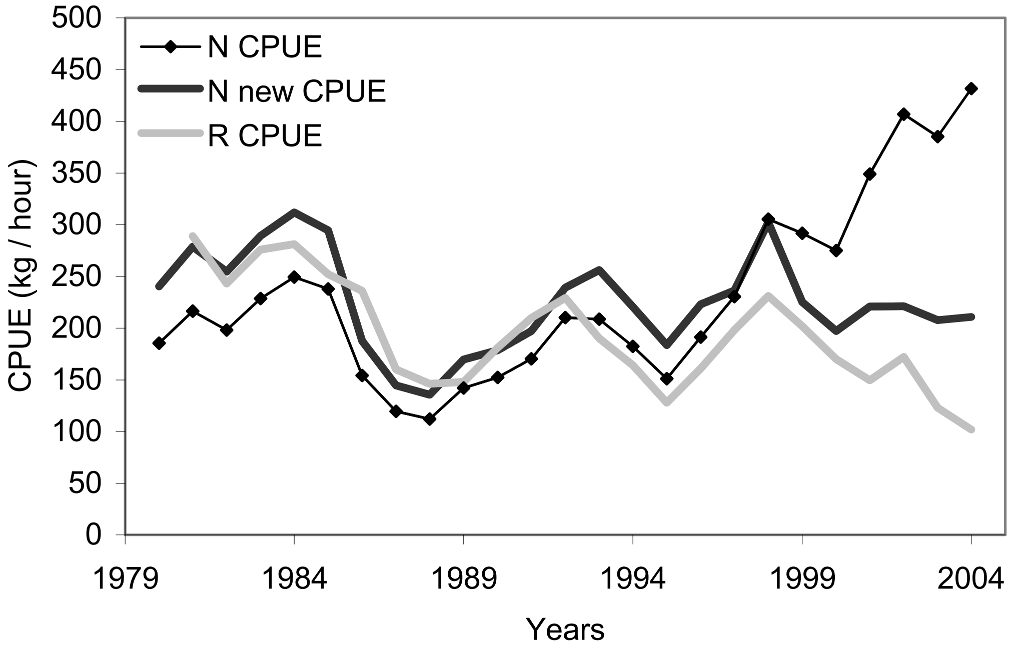


Figure 7.2 Unstandardised Norwegian CPUE (N CPUE), standardised CPUE to vessels with 1000-1550hp and single trawl (N new CPUE) and Russian CPUE (R CPUE) for ICES areas I, IIa and IIb.

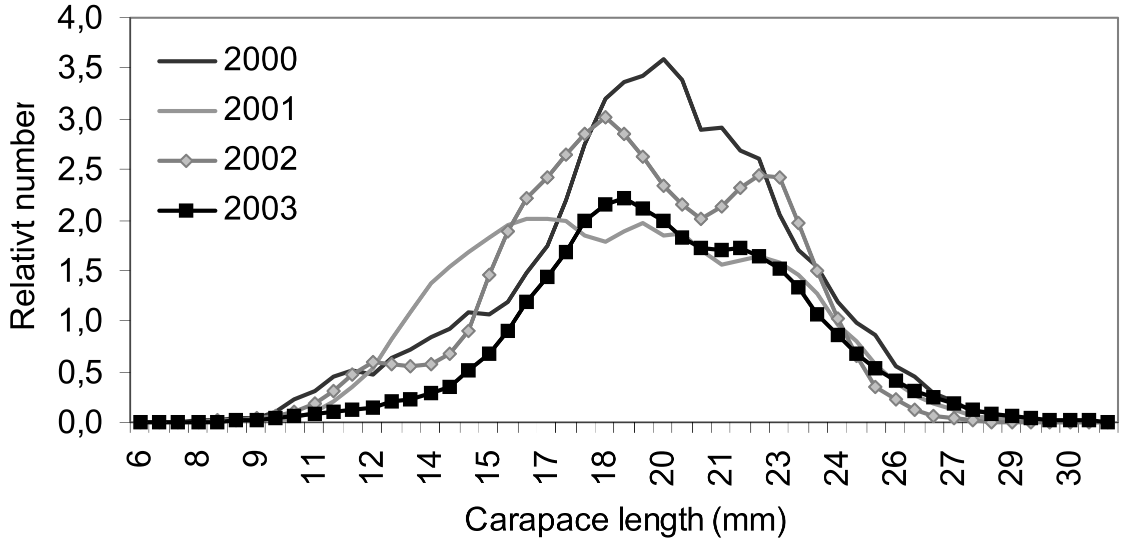


Figure 7.3 Length distribution in Norwegian shrimp catches in 2000 to 2003.

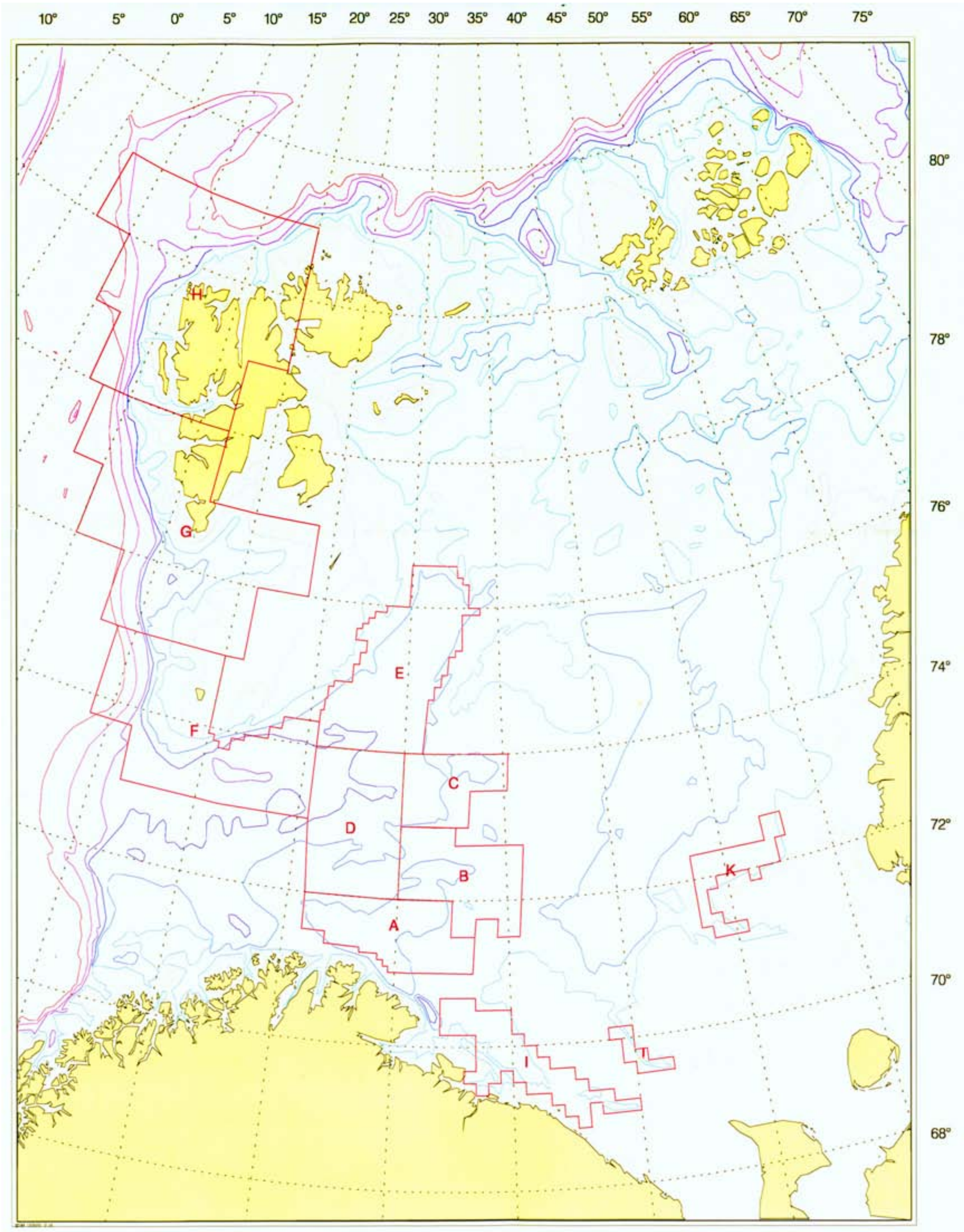


Figure 7.4 Survey strata are combined to 9 larger areas marked with letters A to K. East Finnmark (A), Tiddly Bank (B), Thor Iversen Bank (C), Hopen (E), Bear Island (F), Storfjord Trench (G), Spitsbergen (H), Kola coast (I) and the Goose Bank (K) (Anon., 2003a).

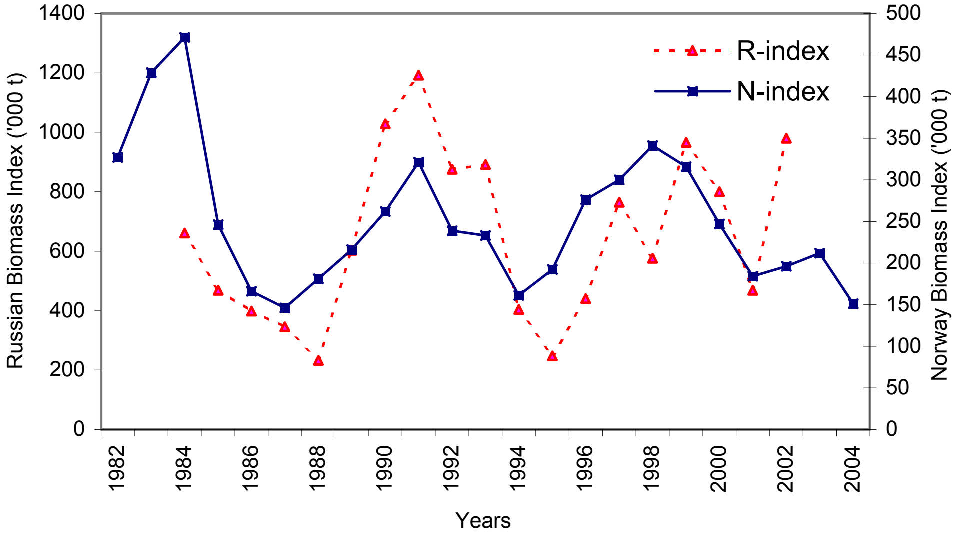


Figure 7.5 Shrimp biomass indices from Norwegian and Russian surveys in the Barents Sea and Spitsbergen area in 1982-2004.

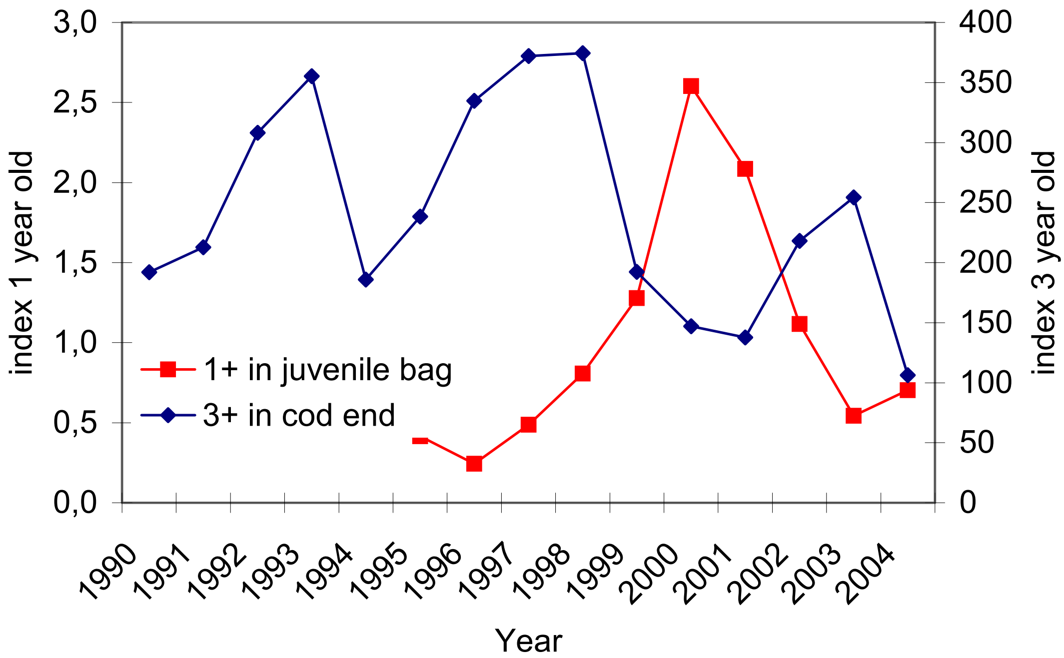


Figure 7.6 Index for one and three year old shrimp in the Norwegian Survey.

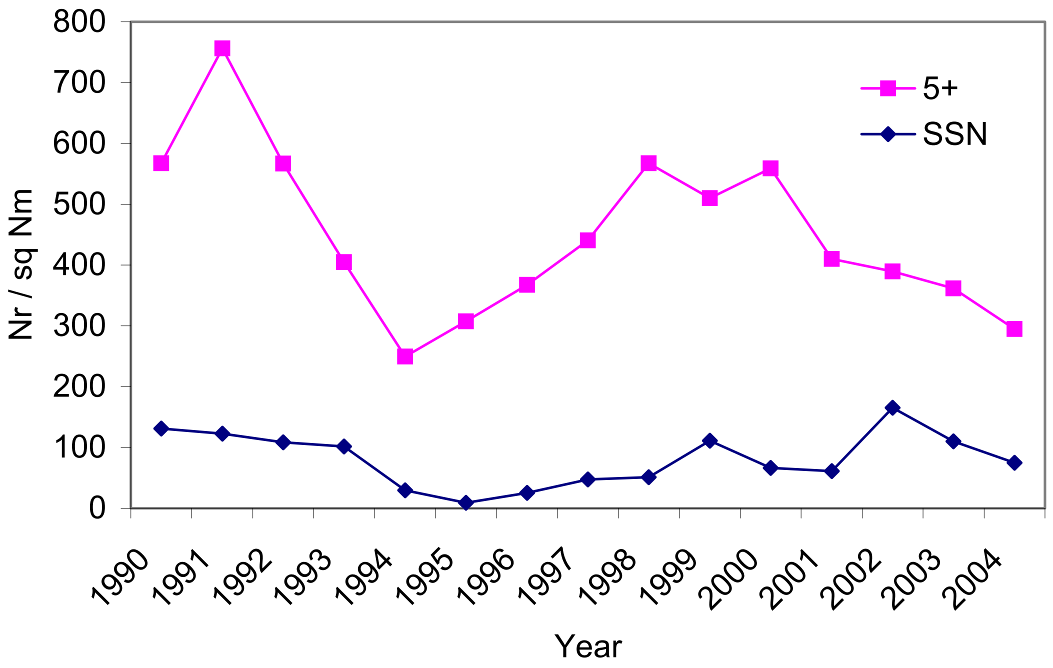


Figure 7.7 Number of individuals aged five or more (5+) and number of egg carrying females (spawning stock number SSn) in the Norwegian Barents Sea survey.

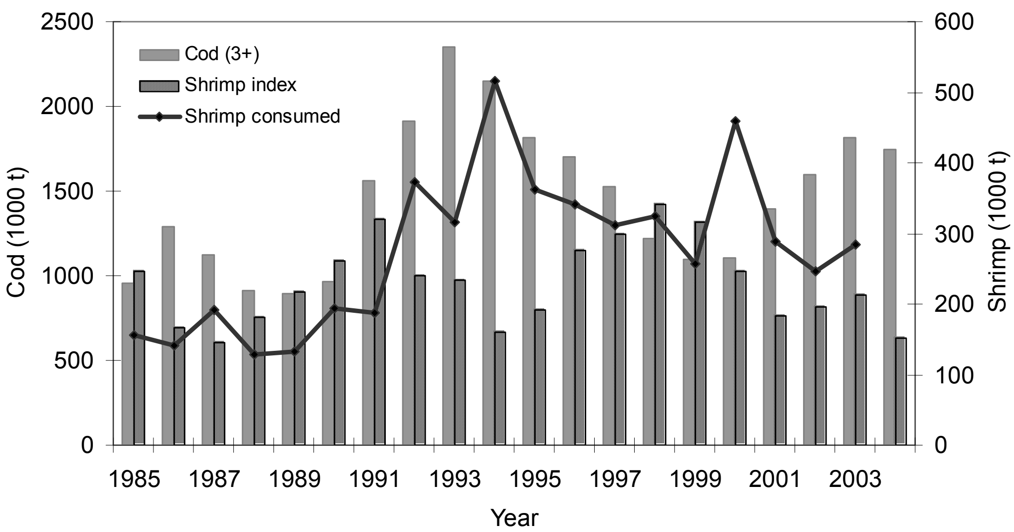


Figure 7.8 Biomass indices from the Norwegian surveys, biomass estimate for cod (age 3 years and older) and the shrimp consumed by the cod in the Barents Sea.

Annex 1 – On the minimal allowable size of the Barent Sea northern shrimp

Working Document # to the Pandalus Assessment Working Group

Copenhagen, 27 October – 04 November 2004

On the minimal allowable size of the Barents Sea northern shrimp

by

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Abstract

Introduction of the total minimal allowable size for the northern shrimp *Pandalus borealis* is not evident and effective, because of non-uniformity of the length-sex composition of the it population in some areas of the Barents Sea and Spitsbergen, as well as reliable differences in the growth rate, the spawning stock size and abundance of young shrimp.

Introduction

The international management of fisheries and assessment of the northern shrimp *Pandalus borealis* stock in the Barents Sea and adjacent waters is carried out predominantly with the use of descriptive summaries of catch statistics, population structure, abundance indexes and expert estimations. This is caused by the lack and low quality of information necessary for the use of analytical stock assessment methods.

There are no yet common standard methods and schemes of development and adoption of decisions on managing the fishery for northern shrimp. The evident lack of fishery statistic information makes also difficult the realization of the precautionary approach to the management of this species stock in the Barents Sea. Management and assessment of most of northern shrimp stocks in different Atlantic areas are also connected with similar problems (Perry et al., 1999; Hvingel and Kingsley, 2000; Koeller et al., 2000; Anon., 2003).

Nevertheless, studying the world experience of fishery for northern shrimp, three main management strategies peculiar for shellfish fishery and other marine organisms can be outlined. Somehow or other, these strategies were tested on the Barents Sea shrimp stock:

1) Limitation of a catch by size/sex;

2) A total allowable catch (TAC);

3) Limitation of fishing efforts.

Realization of a strategy of size/sex limitation is connected with introduction of various protection measures: regulation of fishing gear and techniques, assignment of size limits, minimal mesh sizes in fishing gear and allowable by-catch of marine organisms of illegal size. In some areas of the Barents Sea the limitation of allowable catch is applied. Direct control of the fishing effect consists as a rule in limitation of total fishing effort (a number of fishing days), as well as in introduction of a prohibition of fishery in some areas because of by-catches of young fish or small shrimp. Establishment of by-catch limits indirectly influences the re-distribution of fishing efforts during shrimp fishery.

Grounded choice of the stock regulatory strategy requires a certain scientific information (Table 1). Lack of such information conditions for the application of formal methods of stock status assessment (for example, summaries of catch statistics, methods of time series extrapolation, a method of analogies, "traffic light" method) and makes difficult choosing of criteria and biological reference points.

Table 1. Scientific information needed by each regulatory strategy of northern shrimp fishery management (by Perry et al., 1999)

Regulatory strategy	Necessary information
Size limits	• age at first spawning • ratio "yield per recruit" • natural mortality and growth rate • selectivity of fishing gear and survival of escaped individuals
TAC/quota	• determination of a stock unit • migrations • abundance (by surveys, by analysis of catches per unit effort) • stock distribution and area stratification exploitation rate • rates of growth, mortality and recruitment • catchability
Limitation of fishing efforts	• determination of a stock unit • migrations • recruitment • change of catchability with stock size • growth rate • catch and effort

Various methods of analytical assessment of stock status are approved for most of shrimp fishing grounds, including the Barents Sea. The most popular analyses among cohort models are VPA and LBA (length based analysis); those among production models are modifications of the Stefansson model and those among stochastic models are state-space framework and Bayesian approach (Anon., 2003; Anon., 2003a; Skuladottir and Sigurjonsson, 2004). Status estimation of the Barents Sea population and most of others with the use of the given methods is coupled with the following difficulties:

1) Impossibility of accurate determination of age; analysis of length frequencies permits to determine age approximately;

2) Short life cycle and significant annual dynamics of biomass suggest high mortality, including that from cod predation; this leads to impossibility of the grounded application of biological reference “yield per recruit” (Y/R);

3) Value and variability of natural mortality are much higher than those of fishing mortality; that makes the usage of traditional cohort models difficult;

4) Estimation of total biomass is difficult because of the wide variation of shrimp aggregations density over wide areas, as well as seasonal and spatial dynamics of vertical migrations;

5) A complex structure of the population, diversity of dwelling conditions and dependence of most of sub-populations on the external recruitment impede the application of uniform measures of regulation over the whole area (Berenboim and Lysy, 1987; Aschan et al., 2004).

In spite of these difficulties, for the most of stocks this or that type of a strategy is implemented, which is grounded both with the use of formal and analytical methods. Practically for all stocks, including the Barents Sea one, a strategy of limitation by length/sex is realized through introduction of a minimal mesh size in fishing gear. Minimal mesh size for the shrimp fishery in the Barents Sea is 35 mm, on the Grand Bank of Newfoundland and Flemish Cap – 40 mm, in the Strait of Maine – 44.5 mm (Clark et al., 2000; Anon., 2004).

In the practice of fishery for *P. borealis* in Atlantic waters the minimal length of shrimp as a measure of regulation of fishery was introduced only for the Norwegian Economic Zone (Anon., 2003a). As a result, the Norwegian authorities have been unilaterally closing for many years quite big Spitsbergen areas for the international shrimp fishery because of by-catches of young shrimp (<15 mm by the carapace length in according Norwegian rules) of more than 10 % in weight in some catches. However, on the rest grounds of fishery for the Barents Sea shrimp, as well as in waters of Iceland, Greenland, the USA, Canada and in the NAFO Regulatory Area, such a measure of fishery regulation is not provided for (Clark et al., 2000; Anon., 2004; Bowering and Atkinson, 2004; Siegstad and Hvingel, 2004; Skuladottir and Sigurjonsson, 2004).

The 32nd session of the Joint Russian-Norwegian Fisheries Commission in 2003 had decided to charge scientists of both countries to assess biological conditions for establishing the total minimal allowable size (TMAS) for northern shrimp of the Barents Sea. In order to evaluate the expediency of the total minimal allowable size for northern shrimp of the Barents Sea, we consider in the present paper the length-age structure of shrimp concentrations, sizes of females' maturity, sex ratio and relative abundance of young individuals from some areas of the Barents Sea and Spitsbergen.

Material and Method

Materials used in the paper are those obtained in the Russian trawl surveys of the northern shrimp *Pandalus borealis* in the Barents Sea and Spitsbergen areas in 1989-2002. To conduct a comparative analysis of parameters of growth and sex ratio of the northern shrimp the surveyed area was divided into areas, as it is done during trawl surveys (Aschan et al., 1993; Aschan et al., 2004). In all surveys, a bottom shrimp trawl of the Russian production was used, which had minimal internal mesh size of 40 mm and small-mesh insertion (space between knots is 10-12 mm) and without a sorting grid. Horizontal opening of a trawl is 14.5 m, the vertical one is 5 m. A standard trawling distance equaled to 3 miles was used in surveys; the trawling speed was 2.6-2.7 knots.

Individuals with weight of 1 kg selected accidentally were subjected to a biological analysis, which included the following operations: length measuring and determination of a sex and stages of gonads' maturity (Aschan et al., 1993).

Carapace lengths (CL) for length frequency information were measured from the posterior margin of the eyestalk to the posterior mid dorsal edge of the carapace. Sex of the northern shrimp was determined by the shape of the endopodite of the first pair of pleopods, distribution of sternal spines on the first segment of abdomen and by the presence of roe (Rasmussen, 1953; McCrary, 1971). 50-% maturity (L_{50}) was determined by a method proposed by Skuladottir (1990 and 1998).

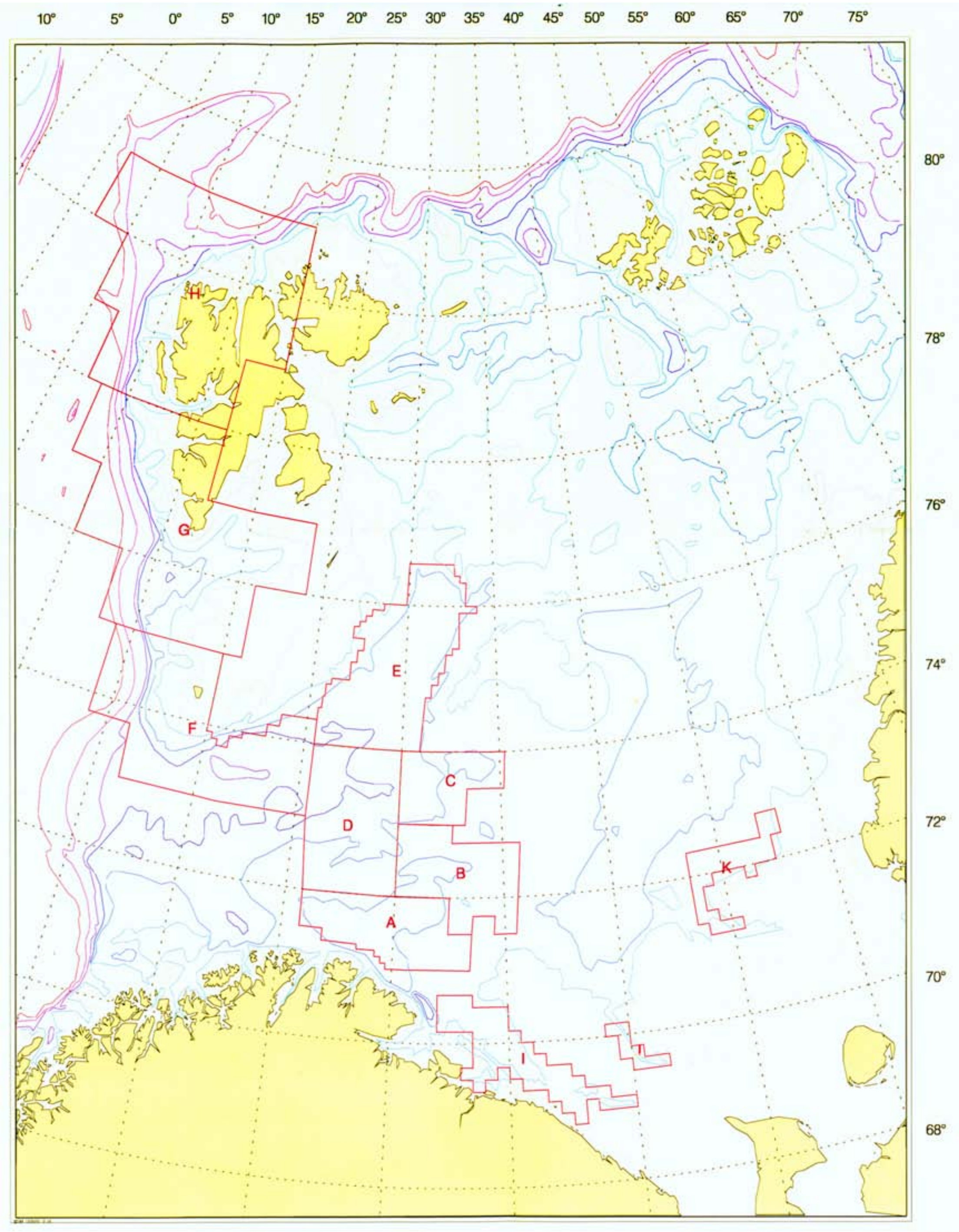

Figure 1. Survey strata are combined to 9 larger areas marked with letters A to K.East Finnmark (A), Tiddly Bank (B), Thor Iversen Bank (C), Hopen (E), Bear Island (F), Storfjord Trench (G), Spitsbergen (H), Kola coast (I) and the Goose Bank (K) (Anon., 2003a).

Data on size-sex composition from each station were combined by areas and years. For each area the length frequency distributions were built up, as well as the percentage ratio was determined between young individuals (<15 mm CL), males, females with sternal spines and females without them. It was assumed during the analysis of size frequencies that each modal group corresponded to the year class. Statistic treatment was carried out in MS Excel with the use of data analysis package. For comparison of mean values, the parametric t-criterion of Student with the confidence interval P=95 % was used considering hypothesis on the normal distribution of a sample's data. To reveal differences in the size-sex structure of the northern shrimp population, mean percentages of young individuals and different sex groups were tested by areas for 1989-2002.

Results

Size distribution of shrimp samples from all surveyed areas is polymodal and asymmetric (Fig. 2). The selected size groups permit to assess more or less accurately the age of individuals in samples. Analysis of size-variation frequencies has shown that during trawl surveys young shrimp occur in catches from the age of 2, as a rule. Sizes of this age group vary in dependence on the area from 10 to 14.5 mm by the carapace length. Shrimp at the age of 1+ occur as single individuals and is presented mainly in areas adjoining to Spitsbergen. Sizes of 1+ shrimp do not usually exceed 10 mm, that agrees well with data of the Norwegian colleagues, who used small-mesh bag (Hansen and Aschan, 2000). 1+ shrimp from catches taken by small-mesh bag are of 6-10 mm by the carapace length.

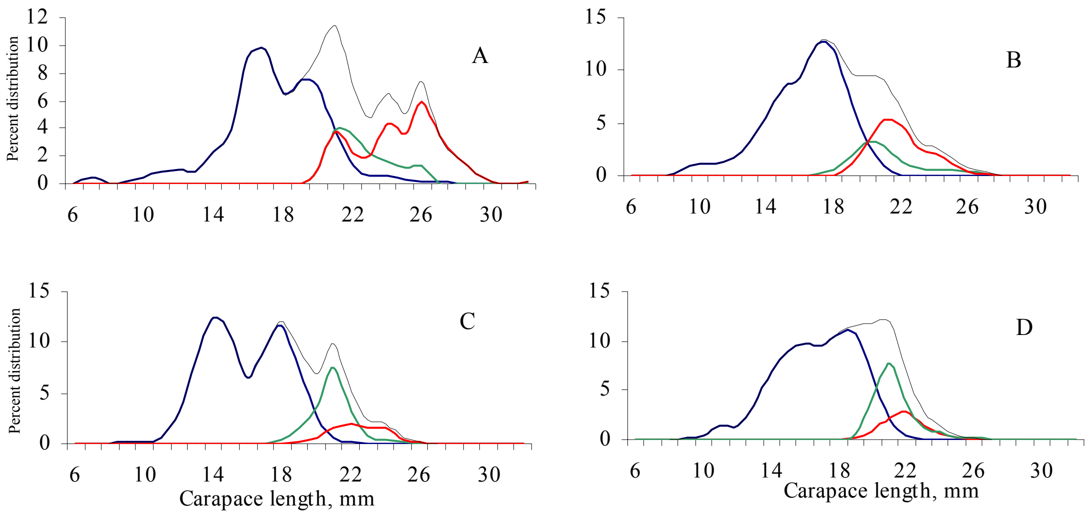

Figure 2. Typical length distributions of P. borealis in the Barents Sea (Spitsbergen (A), Hopen (B), Kola Coast (C) and Goose Bank (D), Russian surveys data for 1993-2000, blue line – males, green – primiparous females, red - multiparous females, black – total).

Analysis of the size structure of catches has revealed 6 age groups in the most areas of investigations. Some years, 7 age groups of shrimp were determined visually, and in the Spitsbergen area – 8-9 age groups. The first and last age groups did not occur in catches every year. Nevertheless, they were being revealed quite often that made possible to determine the average sizes for these ages totally by areas for the whole period of observations. Intervals between modas of year classes, i.e. of age groups, constituted on average 2 mm for the northern areas (the areas of the Bear Island and Spitsberegen) and 3-4 mm for the southern areas (the Kola Coast and Thor Iversen and Tiddly Banks). Older age groups have a big transgression of sizes of individuals of adjacent ages and overlap often each other.

Modal sizes of middle age groups varied by both areas and years. The least modal sizes for the whole period of investigations of northern shrimp at the age of 3-6 were observed for areas of the Bear Island and Spitsbergen. Modal sizes of these ages are lower than long-term means by all areas by 0.2-0.4 mm. The largest sizes of shrimp at the age of 3-8 were in the Hopen Area and in the Kola Coast area.

Strengths of year classes also differ by areas. Nevertheless, in all areas 1-2 age groups are observed, which dominate in catches. For example, on the Goose Bank there mainly shrimp with modal length of 16-18 mm (at the age of 3-4). In some years, year classes with modal size 21-23 mm carapace length (at the age of 5-6) are observed. In the Kola Coast area, three length classes with different abundances during the whole investigated period can be determined. These classes can be conditionally attributed to the age of 3, 4 and 5. In the area of Tiddly and Thor Iversen Banks shrimp were observed with modal sizes 16-19 mm and 20-21 mm. The similar distribution was registered in the Hopen area. However, a portion of shrimp with modal size of 22-24 mm increased there in some years. The Hopen area and Tiddly and Thor Iversen Banks are close to each other. Therefore, the distribution of size-variation frequencies of shrimp catches and strength of year classes in some years have a similar character. In areas of the Bear Island, Storfjord Trench and Spitsbergen, year classes of different strengths were observed in catches, among which shrimp dominated with modal sizes of 14-16, 17-19 and 21-23 mm at the age of 3, 4 and 5.

Mean lengths of shrimp of all sex groups in the area of Spitsbergen are higher than in the Barents Sea (Fig. 3). Minimal mean sizes were in males and females of the Goose Bank shrimp.

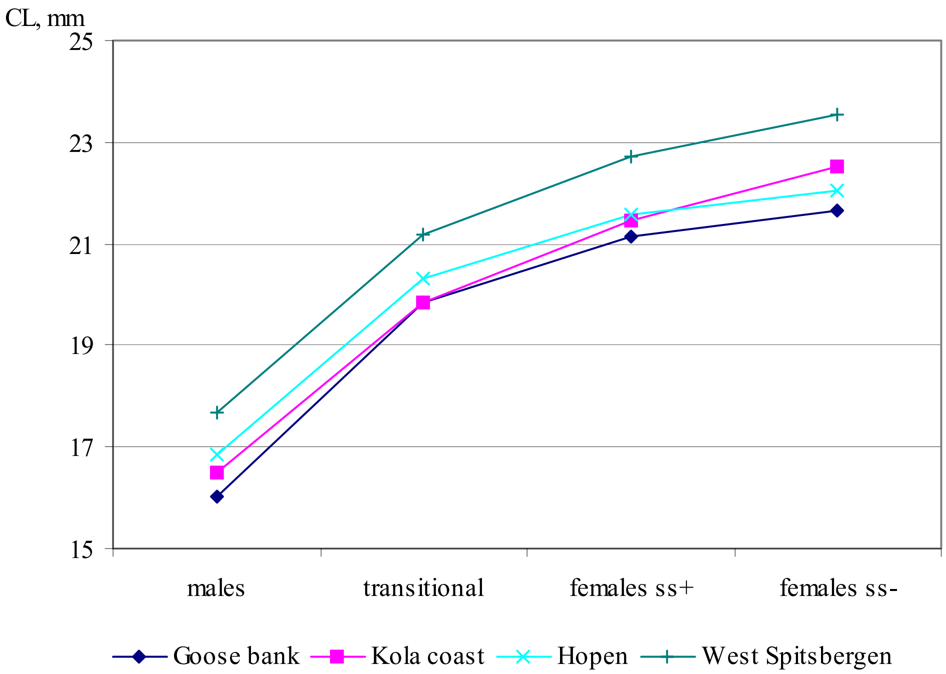

Figure 3. Average carapace length of different sex groups of shrimp *P. borealis* in the Barents Sea and Spitsbergen areas, 1989-2002 (the Russian surveys data).

Analysis of size composition of the northern shrimp caught during the Russian trawl surveys has shown that a by-catch of young shrimp with carapace length less than 15 mm does not exceed on average 3.5 %. High percentage of young shrimp by-catch was registered on the Goose Bank, where it constituted on average 10.3 % for the whole period of investigations (Table 2). Therefore, at the minimal allowable size of 15 mm and a 10-% standard of young shrimp by-catch, the fishery for shrimp on the Goose Bank could be closed. The annual by-catch of young shrimp in this area varied within 1.5-29.7 %. For other areas, this index did not exceed 4.8 %. Quite big year-to-year variability of young shrimp by-catch by areas should be mentioned. Quite often the relative abundance of young shrimp can differ from year to year about ten times. Nevertheless, such a character of dynamics of young shrimp abundance does not lead to big changes of abundance of year classes at the age of 3-4, which dominate in catches.

Table 2. Mean proportions between young northern shrimp, males, females and L_{50} in the Barents Sea and Spitsbergen areas by results of Russian shrimp surveys, 1989-2002.

Area	Young shrimps (< 15 mm), %	Males, %	Primiparous females, %	Multiparous females, %	L50, mm
Spitsbergen	4.8	57.7	26.2	16.1	22.7
Srorfjord Trench	3.2	66.9	26.0	7.1	23.1
Bear Is.	4.4	67.8	16.0	16.2	21.3
Hopen	4.7	67.7	15.6	16.7	21.8
Tidly Bank, Thor Iversen bank	2.6	65.4	15.2	19.4	22.0
Goose bank	10.3	76.4	9.5	14.1	21.2
Kola Coast	4.3	57.5	17.5	25.0	21.6

Ratio between males and females in catches is approximately equal and strives for the proportion 2:1. The exclusion is the Goose Bank, where the ratio constitutes 4:1.

A value of 50-% maturing of the northern shrimp females (L_{50}) in the Barents Sea varies on average within 21.2-22.7 mm. Shrimp with such sizes can be attributed to the age of 5-8. The spawning in the southern areas takes probably place at earlier age than in the northern areas. Differences in the value of L_{50} by areas and years aren't statistically confident. At the same time, the average values of L_{50} of shrimp caught on the Goose Bank, nearby the Bear Island and in the Kola Coast area are lower than those in the Hopen area and on the Tiddly and Thor Iversen Banks.

The relative abundances of sex groups and young shrimp (<15 mm CL) by different areas were objected to the comparative assessment with the use of parametric t-criterion of Student. It was assumed that at the null hypothesis the difference between long-term percentage of sex groups and young individuals by areas is equal to null, and differences between samples are randomicity. In most cases the hypothesis was rejected for the Kola Coast Area and for the Goose Bank. Statistically reliable differences in the relative abundance of shrimp males and females with the sternal spines were observed for the Goose Bank area compared to other areas of the Barents Sea. The reliable differences in the relative abundance of young shrimp were also registered on the Goose Bank and in areas of the Storfjord Trench, Tiddly and Thor Iversen Banks and in the Kola Coast area.

Discussion

The comparative analysis of length-sex characteristics of the Barents Sea shrimp has shown that there are some differences between groups of this species from different areas, which worth being accounted at developing of management strategies.

Length-age characteristics of shrimp differ reliably by areas. In the southern part of the Barents Sea (the Kola Coast area), growth rate of shrimp at the age of 2-4 is 1.5-2 times higher than in the northern part (Spitsbergen and Storfjord Trench). Differences in growth rates of shrimp from different areas of the Barents Sea have already been observed earlier (Rasmussen, 1953; Teigsmark, 1983; Hansen and Aschan, 2000), as well as in the Icelandic waters (Skuladottir, 1999).

In accordance with data of the Russian trawl surveys, the basis of catches in most areas of the Barents Sea consists of individuals longer than 16-17 mm. Nevertheless, the strength of length year classes differs noticeably by areas and for the whole period of observations on average. Large portion of young shrimp (12-16 mm) is registered in catches in the southern and eastern Barents Sea (the Kola Coast area and Goose Bank); in the northern areas this portion is less.

For the length composition of shrimp catches from the Kola Coast area the polymodal structure is peculiar with well-defined 3-4 year classes (see fig. 2). In this area, both young and older age groups are well presented. As a rule, 1-2 modas in the range of 18-24 mm are observed in the length composition of shrimp concentrations in the Hopen area.

Abundance of the same year classes of the northern shrimp is different in the length composition of concentrations from different areas. Sizes of shrimp in catches of adjacent areas have different modal groups very often, as well as different numbers of modas.

Such differences in the length-age characteristics of catches from different areas are connected to our opinion with the following reasons: varying level of sub-populations reproduction, i. e. different degrees of spawning stock recruitment in these areas, different year-to-year variations of intensity of recruitment with recruits from outside and probable different natural mortality, which is mainly related to predation of cod (Berenboim et al., 2000), as well as, probably, to different exploitation intensity of the population in different parts of the sea. Results of fecundity investigations, as well as of other reproduction properties of the Barents Sea northern shrimp, demonstrate different reproduction abilities of sub-populations (Berenboim, 1989; Berenboim and Sheveleva, 1989).

All population of shrimp *P. borealis* nearby the northeastern border of the Atlantic part of the area is a part of a super(meta)population consisted of a complex spatially discontinuous sub-populations, which have different abilities to self-reproduction and connected to each other by larvae drift. Intensity and direction of larvae drift influence also the recruitment of shrimp stock in different areas of the sea (Berenboim, 1982, 1992; Berenboim and Lysy, 1987).

For the area of the Goose Bank compared to other areas, the difference in the ratio between females and males is big. Most part of males there does not reach a female stage, probably, because of the unfavourable hydrological conditions.

Compared to the Goose Bank and the northern areas of the sea (the Hopen area), higher portion of females is observed in catches in the Kola Coast area that can be connected with relatively high growth rate of shrimp there.

For majority of areas, the introduction of a TMAS of 15 mm will not apparently influence positively the stock status and will not be an effective measure of fishery regulation. Attempts to assess the consequences of introduction of such a standard have been made earlier (Berenboim, 1989). In the 1980's, by-catch of young shrimp less than 15 mm CL did not exceed 4.7 %. Such a low by-catch and peculiarities of a population structure of the Barents Sea northern shrimp permitted to conclude that at fishery for shrimp by fishing gear with minimal mesh size of 35 mm there is no need to introduce the additional fishery regulation measure like a minimal allowable size and limitation of a portion of small shrimp.

More over, in the case of introduction of the TMAS for the Barents Sea shrimp, the shrimp fishery on the Goose Bank can be in some years prohibited. And, the Goose Bank area, being an dependent sub-population with relatively low portion of spawning females, presents a dwelling area with a low reproduction potential. Therefore, the introduction here of a minimal allowable size of shrimp in order to conserve the spawning stock will have very low effectiveness. Besides, there are reasons to think that introduction of allowable size of 15 mm by the carapace length will provoke the increase of young shrimp discards.

Minimal allowable size, as a conservation measure aimed at protection of the spawning stock, should not be less than average sizes of individuals, which gave a generation at least two times. Northern shrimp should participate in the spawning at least two times: at first, as a male, after that as a female. The application of such approach for the northern shrimp shows that they should be fished beginning from the age of mass transformation of primiparous females into multiparous females. In this case, the total minimal allowable size under the Barents Sea conditions would constitute about 22 mm by the carapace length. However, the usage of such length as minimal allowable size would lead to the loss of more than half of catch.

If to assume that the introduction of a TMAS is aimed at the conservation of recruitment, then specific distribution of the northern shrimp and a character of their fisheries will not permit to feel the effect of introduction of this fisheries measure. It is known that immature young individuals remain mainly in the water body, in the zone inaccessible for the bottom trawl fisheries. In some areas young individuals prefer areas with less depths than adult mature individuals (Aschan, 2000; Hansen and Aschan, 2000). If necessary, such areas can be closed for fisheries by means of special instructions as it is done for example in the shallow waters of the Flemish Cap Bank (Anon., 2004).

To our opinion, at different stock exploitation degree different scenarios of its management may be used including introduction of a minimal allowable size. A rational approach to solving of this problem requires developing and introducing of:

1) Criteria of a rate of stock exploitation or types of biological reference points with different zones of the stock status;

2) Regulation schemes for each level of the sock exploitation.

The historic experience of gradual introduction of different fish conservation measures shows that very often the first regulation act of fishery for fish and shellfish is establishing of a minimal mesh size of the fishing gear and (or) minimal allowable size (Perry et al., 1999; Sokolov, 2001). Later on, the regulation scheme included various measures on limitation of catch and effort. In the middle of the 1990's, schemes of rational exploitation of water bioresources from the point of view of the precautionary approach were developed. In accordance with idea of the precautionary approach for the long-term successful exploitation of the stock, the regulation measures should correspond to the stock status; i. e. for each level of the stock exploitation the corresponding complex of fish conservation measures should be applied.

At the same time, the fishery for the northern shrimp by various countries is mainly directed to the catch of the largest individuals, since their price in the world market is much higher than that of the small shrimp. Therefore, fishermen do not desire to use during fishery for shrimp the trawls with less mesh size than fishing rules require. On the other hand, a wish to use only large individuals increases the probability of small individuals discards. At the fishery for shrimp in the North Sea (the ICES Areas IV and IIIA) two types of discards are distinguished (Anon., 2004a). The first type of discards consists of individuals of the least sizes separated during the technological processing and not used by the Norwegian and Swedish industries. It is reckoned that shrimp with carapace length less than 15 mm are separated and not delivered to the world market. The second type of discards was recently marked out and connected with quite high difference in price for the large boiled shrimp and shrimp of middle sizes, which are delivered fresh to the port. Recent time, a portion of shrimp of middle size increased in catches, which can constitute together with fractions of small shrimp from 2 to 11 % of the yearly catch by estimations of the ICES Working Group.

By the present moment, there are no data on discards for the Barents Sea area. A problem of the stock exploitation rate is still debatable as well. By some data, the coefficient of the fishing mortality for the recent 20 years varied within 0.06-0.37 for the age of 2-5 (Berenboim et al., 2000). However, calculations of the fishing mortality coefficient are carried out with quite large suppositions and cannot be the absolute fishing indices. It is known that total catch of shrimp in the Barents Sea and adjacent waters is for the recent 2-3 years less than the long-term mean indices for the recent 20 years (Aschan et al., 2004). In the middle of the 1980's the catch exceeded 100 thou. t. Nevertheless, no signs of the stock overexploitation were observed. By results of the Russian and Norwegian surveys, the biomass dynamics corresponded to the 7-8-year cycles, and no adequate response to the fishing effort was recorded.

On the basis of the mentioned above one can conclude that there is no evidence to the necessity of introduction of a minimal allowable size at the reached level of fisheries exploitation of the stock.

Conclusions

Northern shrimp is one of few water animals' species, for which no minimal allowable sizes were introduced almost in all areas of their fishing. There are some objective positions stipulated by biological and marketing peculiarities of the species, at which the introduction of total minimal allowable size for the Barents Sea northern shrimp is not considered as the obvious measure, even at the intensive exploitation of stocks.

1. Minimal allowable size, as a conservation measure aimed at protection of the spawning stock, should not be less than average sizes of individuals, which gave a generation at least two times: at first, as a male, after that as a female. In this case, the minimal allowable size under the Barents Sea conditions would constitute about 22 mm by the carapace length. However, the usage of such length as minimal allowable size would lead to the loss of more than half of catch.
2. Introduction of the total minimal allowable size for the northern shrimp in the Barents Sea will increase the danger of discards of small shrimp from board of vessels where sorting of catches is used.
3. Since the length-sex composition of the spawning stock of the Barents Sea northern shrimp population is inhomogeneous and its distribution is uneven, it is not expedient to introduce a total minimal allowable size for the whole area of the population.

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Annex 2 - The Spanish NE Arctic Shrimp Fishery in 2003

Working document

ICES *Pandalus* Working Group, 2004

The Spanish NE Arctic Shrimp Fishery in 2003

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In 2003 year, the Spanish fleet targeting for shrimp was composed only by two freezer trawlers HP (1650-2000) that worked from June to December in Svalbard area (ICES Division IIb). The gear used was a simple trawl with sorting grates and a mesh size of 40-45 mm in the codend. All the hauls were carried out in depths between 200 and 500 meters. Catch and effort data for the whole fleet has been collected from the Spanish Fisheries Administration and adjusted according to the data gathered by the observers on board.

In the last quarter of the year one scientific observer recorded the catches of the most important species, fishing effort (hours) and main biological data of shrimp (oblique carapace length, sex and maturity stage) from samples obtained in one of the two vessels.

The table 1 shows the catches and yields of shrimp by quarter and division as well as the distribution of effort (Number of active units and number of days and hours of activity). Also the catches of the others species (by-catch and discarded) were estimated from the vessel where the scientific observer was present.

The peak of activity and biggest yields (around 210 kg/h) were located mainly at the end of the summer and the beginning of the autumn.

The table 2 and figure 1 show the length distribution of shrimp catches as percentage by quarters.

Table 1. Nominal shrimp catches (kg) and by-catch of the main species caught by quarter of the Spanish trawl fleet directed to shrimp fishery in Svalbard area (ICES Division IIb) in 2003. Also the effort and yields of shrimp (kg/h) are shown.

SPECIES	1st	2nd	3rd	4th	Total[1]
ICES DIVISION IIb					
Shrimp		2334	242892	122879	368105
Greenland halibut				158	474
Polar cod				6971	20883
Long rough dab				572	1714
Redfish				263	787
Capelin				1001	2999
Blue whiting				224	672
Cod				1000	2995
Haddock				294	881
Thorny skate				249	745
Number of vessels		1	2	1	2
Fishing days		1	59	31	91
Fishing hours		19	1121	589	1729
CPUE Shrimp (kg/h)		123	217	209	213

[1] Total by-catch estimated from the by-catch observed by scientific observed on board in the last quarter.

Table 2: Length distribution of Artic Shrimp from Spanish catches in ICES Division IIb, 2003.

Length (mm)	**2nd**		**3rd**		**4th**		**Total IIb**	
	males	**females**	**males**	**females**	**males**	**females**	**males**	**females**
8.5	874		90959		46016		137849	
9.0	2706		281579		142451		426735	
9.5	3615		376175		190307		570097	
10.0	3439		357886		181054		542379	
10.5	5912		615212		311235		932359	
11.0	6205		645737		326678		978620	
11.5	5852		609029		308108		922989	
12.0	8589		893873		452210		1354672	
12.5	7416		771771		390439		1169626	
13.0	11009		1145633		579576		1736218	
13.5	11128		1158088		585876		1755092	
14.0	15145		1576137		797368		2388650	
14.5	22704		2362741		1195310		3580755	
15.0	25057		2607625		1319197		3951879	
15.5	22210		2311278		1169275		3502763	
16.0	32979	271	3431977	28160	1736236	14246	5201192	42677
16.5	35075		3650128		1846599		5531801	
17.0	38060		3960818		2003777		6002655	
17.5	32091		3339591		1689498		5061181	
18.0	26828	140	2791896	14614	1412419	7393	4231143	22147
18.5	27805	360	2893625	37427	1463884	18934	4385315	56721
19.0	25305	1115	2633382	116061	1332227	58715	3990914	175891
19.5	19485	2029	2027772	211120	1025849	106806	3073106	319954
20.0	18643	2008	1940090	208986	981491	105726	2940224	316721
20.5	16867	2976	1755267	309688	887989	156671	2660123	469335
21.0	12788	3700	1330791	385095	673247	194820	2016825	583615
21.5	5949	4879	619132	507788	313219	256890	938300	769557
22.0	3668	7365	381728	766489	193116	387767	578512	1161621
22.5	1645	11669	171238	1214331	86629	614330	259512	1840330
23.0	565	14873	58776	1547797	29735	783030	89075	2345700
23.5	864	11636	89905	1210938	45483	612613	136252	1835188
24.0	293	13721	30448	1427868	15404	722358	46145	2163946
24.5		7590		789881		399601		1197072
25.0		7037		732352		370497		1109886
25.5		3015		313775		158739		475529
26.0		1180		122783		62116		186078
26.5		1885		196121		99217		297223
27.0		1221		127050		64274		192545
27.5		506		52684		26653		79842
28.0		535		55678		28168		84381
28.5		404		42054		21275		63734
29.0		42		4370		2211		6623
29.5		8		797		403		1208
30.0		11		1170		592		1773
Total number	*450771*	*100177*	*46910288*	*10425077*	*23731903*	*5274044*	*71092961*	*15799297*
Total catch (kg)	*2334*		*242892*		*122879*		*368105*	
Catches Sampled *(kg)*					*8436*		*8436*	
Nº Samplings					*15*		*15*	
Nº. Spec. Sampled					3382		3382	

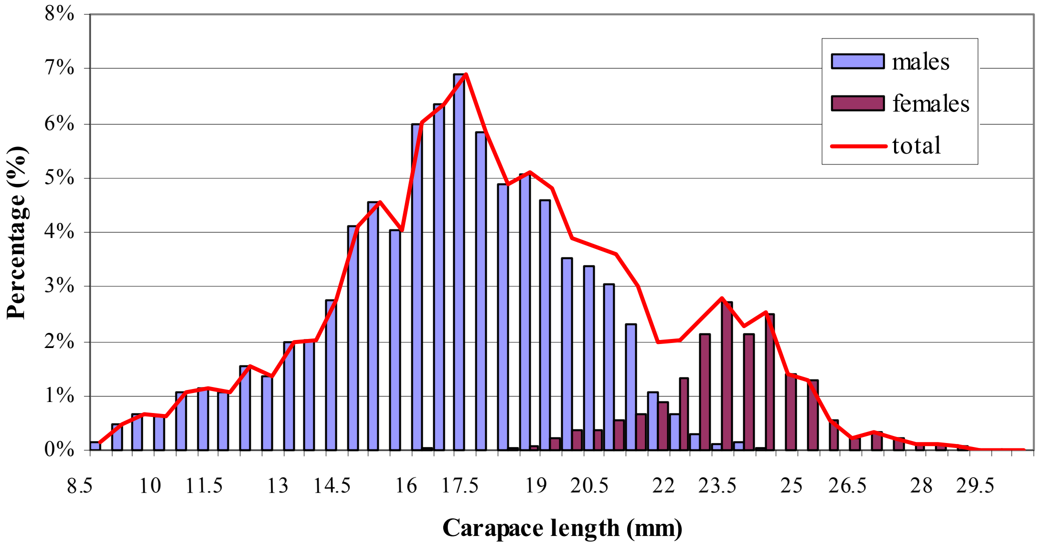

Figure 1. Length distribution of shrimp in ICES División IIb from samples obtained in November 2003.

Appendix 1 – Participants list

***Pandalus* Assessment Working Group**

ICES, Headquarters, 27 October - 5 November 2004

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WG Pandalus 2004-11-06

Review report

Regarding the process the benefits of having a joint meeting with the NAFO is stated by the WG to be less than hoped for due to the (unexpected) lack of crucial data. The WG however recommends a continuation of the joint meeting in 2005. It may be noted that the benefits from joint meetings should actually be expected to be even higher when a WG is in a situation of change, being forced to take new approaches due to changed data access. That this turned out not to be the case may be due to the need for the WG to use more time to address the new situation. It might be useful if a future joint meeting was based on a clear understanding of what aspects of the work are expected to benefit from the joint meeting and an agenda developed which ensures that there is interaction on these aspects.

Stock identity issues: the WG recommends data for genetic analysis to be collected from Norwegian surveys. Should this lead to terms of reference for ICES groups or is it an internal note for the Norwegian researchers?

Stock in IVa east and IIIa

It is indicated that discards practices may be changing towards larger volumes and the WG expresses expectation that data will be available from the ongoing discard sampling programmes. However, it is also indicated elsewhere that few shrimp trips are covered by these programmes and not all fisheries are included. Will such data be forthcoming or should one do more than expect that data will be forthcoming?

The reasoning around the stock status depends presently (in the interim between two survey series) very much on LPUE information. It is a serious cause for concern that the explanation about how LPUE data are generated gives rise to comments from the WG with strong reservations about their representativity. The WG mentions technological changes which would have implications for catchability but the extent of these changes is not known. This is a serious concern when these LPUE data are later used as indicators of stock status.

The main problem with this years assessment is the discontinuity of the Norwegian survey data due to a change in vessel/gear in 2003 and change in timing in 2004. Until a new continuity has been established through intercalibration or through the new series being long enough to judge stock trends the assessment will be entirely dependent on commercial LPUE's which seem to be poorly estimated or influenced by technical changes the extent of which are not known. The WG also expresses concerns about the surplus production model used in recent years, independently of the availability of survey data. The WG does not indicate the direction for a replacement model but it seems that there is a need for considerable intersessional work if this stock is to be subject to analytical assessments again. The WG should make a plan of how to to address the three major issues in the next few years – reestablishment of a survey series, development of commercial LPUE's which are representative and with better known relation to stock trends (or with better descriptors of possible changes in catchability) and development of a new approach to assessments.

The conclusion seems to be that the assessment for this stock has lost its survey series for the time being, that the relation between commercial LPUE data and stock trends is shaky and that the assessment model used in the past suffers some problems which needs to be addressed before a new analytical assessment can be undertaken. This basically indicates that there is very little to go on in terms of advice. The approach taken by the WG by largely relying on LPUE’s for the stock and effort trends for exploitation is probably the only possible in the present situation but can only form a basis for a decision whether a precautionary TAC is justified or not.

Stock on Fladen Ground and Farn deep

No comments

Barents Sea stock

The WG highlights the existing data problems including the lack of adequate length information from catches and discontinuation of one survey and less effort in another. However, it is also stated that some size related data exist and that the discontinued survey was strongly correlated with the survey which has been maintained. When assessment approaches are developed for this stock in the future it should be investigated what can be done on basis of these existing data. There may be a middle way between the size structured analytical assessment which the WG seems to aim for, requiring full length information, and not trying to use the existing information more analytically.